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DEPARTMENT OF ENERGY

10 CFR Parts 429 and 430

[EERE-2021-BT-TP-0030]

RIN 1904-AF29

Energy Conservation Program: Test Procedure for Test Procedures for Central Air Conditioners and Heat Pumps

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Notice of proposed rulemaking and request for comment.

SUMMARY: The U.S. Department of Energy ("DOE") proposes to amend the test procedures for central air conditioners and heat pumps that will be required for certification of compliance with applicable energy conservation standards starting January 1, 2023 to address a limited number of specific issues. DOE is seeking comment from interested parties on the proposal.

DATES: DOE will accept comments, data, and information regarding this proposal no later than **[INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*]**. See section V, "Public Participation," for details. DOE will hold a webinar on Monday, April 18, 2022, from 1 p.m. to 4 p.m. *See* section V, "Public Participation," for webinar registration information, participant instructions, and information about the capabilities available to webinar participants.

ADDRESSES: Interested persons are encouraged to submit comments using the Federal eRulemaking Portal at *www.regulations.gov*. Follow the instructions for submitting comments. Alternatively, interested persons may submit comments, identified by docket number EERE–2021–BT–TP-0030 by any of the following methods:

1. *Federal eRulemaking Portal*: *www.regulations.gov*. Follow the instructions for submitting comments.
2. *E-mail*: to *CentralACHeatPumps2021TP0030@ee.doe.gov*. Include docket number EERE–2021–BT–TP-0030 in the subject line of the message.

No telefacsimiles ("faxes") will be accepted. For detailed instructions on submitting comments and additional information on this process, see section V of this document.

Although DOE has routinely accepted public comment submissions through a variety of mechanisms, including postal mail and hand delivery/courier, the Department has found it necessary to make temporary modifications to the comment submission process in light of the ongoing COVID-19 pandemic. DOE is currently suspending receipt of public comments via postal mail and hand delivery/courier. If a commenter finds that this change poses an undue hardship, please contact Appliance Standards Program staff at (202) 586-1445 to discuss the need for alternative arrangements. Once the COVID-19 pandemic health emergency is resolved, DOE anticipates resuming all of its regular options for public comment submission, including postal mail and hand delivery/courier.

Docket: The docket, which includes *Federal Register* notices, public meeting attendee lists and transcripts, comments, and other supporting documents/materials, is available for review at *www.regulations.gov*. All documents in the docket are listed in the *www.regulations.gov* index. However, some documents listed in the index, such as those containing information that is exempt from public disclosure, may not be publicly available.

The docket web page can be found at *www.regulations.gov/docket/EERE-2021-BT-TP-0030*. The docket web page contains instructions on how to access all documents, including public comments, in the docket. See section V for information on how to submit comments through *www.regulations.gov*.

FOR FURTHER INFORMATION CONTACT:

Ms. Catherine Rivest, U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Building Technologies Office, EE-2J, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-7335. E-mail *ApplianceStandardsQuestions@ee.doe.gov*.

Mr. Pete Cochran, U.S. Department of Energy, Office of the General Counsel, GC-33, 1000 Independence Avenue, SW., Washington, DC, 20585-0121. Telephone: (202) 586-9496. E-mail: *peter.cochran@hq.doe.gov*.

For further information on how to submit a comment, review other public comments and the docket, or participate in a public meeting, contact the Appliance and Equipment Standards Program staff at (202) 287-1445 or by e-mail: *ApplianceStandardsQuestions@ee.doe.gov*.

SUPPLEMENTARY INFORMATION:

DOE proposes to maintain the following previously approved incorporations by references in 10 CFR part 430:

ANSI/AHRI 210/240–2008 with Addenda 1 and 2, 2008 Standard for Performance Rating of Unitary Air-Conditioning & Air-Source Heat Pump Equipment, ANSI approved October 27, 2011;

ANSI/AHRI 1230–2010 with Addendum 2, 2010 Standard for Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment, ANSI approved August 2, 2010.

Copies of AHRI 210/240–2008 and AHRI 1230–2010 can be obtained from the Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, (703) 524–8800, or by going to *www.ahrinet.org*.

ANSI/ASHRAE 23.1–2010, Methods of Testing for Rating the Performance of Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant, ANSI approved January 28, 2010;

ANSI/ASHRAE Standard 37–2009, Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment, ANSI approved June 25, 2009;

ANSI/ASHRAE 41.1–2013, Standard Method for Temperature Measurement, ANSI approved January 30, 2013;

ANSI/ASHRAE 41.2-1987 (Reaffirmed 1992), “Standard Methods for Laboratory Airflow Measurement,” ANSI approved April 20, 1992;

ANSI/ASHRAE 41.6–2014, Standard Method for Humidity Measurement, ANSI approved July 3, 2014;

ANSI/ASHRAE 41.9–2011, Standard Methods for Volatile-Refrigerant Mass Flow Measurements Using Calorimeters, ANSI approved February 3, 2011;

ANSI/ASHRAE 116–2010, Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps, ANSI approved February 24, 2010.

Copies of ASHRAE 23.1–2010, ANSI/ASHRAE 37–2009, ANSI/ASHRAE 41.1–2013, ASHRAE 41.2-1987 (RA 1992), ASHRAE 41.6–2014, ASHRAE 41.9–2011, and ASHRAE 116–2010 can be purchased from *www.ashrae.org/resources--publications*.

ANSI/AMCA 210–2007, ANSI/ASHRAE 51–2007, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating, Figure 2A and Figure 12, ANSI approved August 17, 2007.

Copies of AMCA 210–2007 can be purchased from *www.amca.org/store/index.php*.

For a further discussion of these standards, see section IV.M of this document.

Table of Contents

I. Authority and Background

Central air conditioners ("CACs") and central air conditioning heat pumps ("HPs") (collectively, "CAC/HPs") are included in the list of "covered products" for which DOE is authorized to establish and amend energy conservation standards and test procedures (42 U.S.C. 6292(a)(3)). DOE's energy conservation standards and test procedures for CAC/HPs are currently prescribed at title 10 of the Code of Federal Regulations ("CFR"), part 430 section 32(c), and 10 CFR part 430 subpart B appendices M ("Appendix M") and M1 ("Appendix M1"). The following sections discuss DOE's authority to establish test procedures for CAC/HPs and relevant background information regarding DOE's consideration of test procedures for this product.

A. Authority

The Energy Policy and Conservation Act, as amended ("EPCA"),[1] authorizes DOE to regulate the energy efficiency of a number of consumer products and certain industrial equipment. (42 U.S.C. 6291–6317) Title III, Part B[2] of EPCA established the Energy Conservation Program for Consumer Products Other Than Automobiles, which sets forth a variety of provisions designed to improve energy efficiency. These products include CAC/HPs,[3] the subject of this document. (42 U.S.C. 6292(a)(3))

The energy conservation program under EPCA consists essentially of four parts: (1) testing, (2) labeling, (3) Federal energy conservation standards, and (4) certification and enforcement procedures. Relevant provisions of EPCA specifically include

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[1] All references to EPCA in this document refer to the statute as amended through the Energy Act of 2020, Pub. L. 116-260 (Dec. 27, 2020).
[2] For editorial reasons, upon codification in the U.S. Code, Part B was redesignated Part A.
[3] This rulemaking uses the term "CAC/HP" to refer specifically to central air conditioners (which include heat pumps) as defined by EPCA. (42 U.S.C. 6291(21))

definitions (42 U.S.C. 6291), test procedures (42 U.S.C. 6293), labeling provisions (42 U.S.C. 6294), energy conservation standards (42 U.S.C. 6295), and the authority to require information and reports from manufacturers (42 U.S.C. 6296).

The Federal testing requirements consist of test procedures that manufacturers of covered products must use as the basis for: (1) certifying to DOE that their products comply with the applicable energy conservation standards adopted pursuant to EPCA (42 U.S.C. 6295(s)), and (2) making representations about the efficiency of those consumer products (42 U.S.C. 6293(c)). Similarly, DOE must use these test procedures to determine whether the products comply with relevant standards promulgated under EPCA. (42 U.S.C. 6295(s))

Federal energy efficiency requirements for covered products established under EPCA generally supersede State laws and regulations concerning energy conservation testing, labeling, and standards. (42 U.S.C. 6297) DOE may, however, grant waivers of Federal preemption for particular State laws or regulations, in accordance with the procedures and other provisions of EPCA. (42 U.S.C. 6297(d))

Under 42 U.S.C. 6293, EPCA sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered products. EPCA requires that any test procedures prescribed or amended under this section be reasonably designed to produce test results which measure energy efficiency, energy use or estimated annual operating cost of a covered product during a representative average use cycle or period of use and not be unduly burdensome to conduct. (42 U.S.C. 6293(b)(3))

If the Secretary determines, on her own behalf or in response to a petition by any interested person, that a test procedure should be prescribed or amended, the Secretary shall promptly publish in the *Federal Register* proposed test procedures and afford interested persons an opportunity to present oral and written data, views, and arguments with respect to such procedures. (42 U.S.C. 6293(b)(2)) The comment period on a proposed rule to amend a test procedure shall be at least 60 days and may not exceed 270 days. *Id.* In prescribing or amending a test procedure, the Secretary shall take into account such information as the Secretary determines relevant to such procedure, including technological developments relating to energy use or energy efficiency of the type (or class) of covered products involved. (*Id.*)

DOE's regulations at 10 CFR 430.27 provide that any interested person may seek a waiver from the test procedure requirements if certain conditions are met. A waiver allows manufacturers to use an alternate test procedure in situations in which the DOE test procedure cannot be used to test the product or equipment, or use of the DOE test procedure would generate unrepresentative results. 10 CFR 430.27(a)(1). DOE's regulations at 10 CFR 430.27(l) require that as soon as practicable after the granting of any waiver, DOE will publish in the *Federal Register* a NOPR to amend its regulations so as to eliminate any need for the continuation of such waiver. As soon thereafter as practicable, DOE will publish in the *Federal Register* a final rule. 10 CFR 430.27(l). DOE is publishing this NOPR for the limited purpose of addressing its obligations under the waiver process regulations at 10 CFR 430.27.

B. Background

As discussed, DOE's existing test procedures for CAC/HPs appear at appendix M and appendix M1 (both titled "Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps").

On January 5, 2017, DOE published a final rule regarding the Federal test procedure for CAC/HPs. 82 FR 1426 ("January 2017 Final Rule"). The January 2017 Final Rule amended appendix M and established appendix M1, use of which is required beginning January 1, 2023 for any representations, including compliance certifications, made with respect to the energy use or efficiency of CAC/HPs. appendix M provides for the measurement of the cooling and heating performance of CAC/HPs using the seasonal energy efficiency ratio ("SEER") metric and heating seasonal performance factor ("HSPF") metric, respectively. appendix M1 specifies a revised SEER metric (*i.e.*, SEER2) and a revised HSPF metric ("HSPF2").

Since the publication of the January 2017 Final Rule, DOE has granted various petitions for waiver and interim waiver from certain provisions of appendix M and/or M1.[4] Additionally, DOE has become aware of certain provisions in appendix M1 for which additional detail and direction may be needed to avoid potential confusion and reduce test burden. Therefore, DOE is proposing changes to improve the functionality of appendix M1 to address these issues.

In addition, on May 8, 2019, AHRI submitted a comment responding to the notice of proposal to revise and adopt procedures, interpretations, and policies for consideration of new or revised energy conservation standards (2020 Process Rule NOPR, 84 FR 3910, Feb. 13, 2019). The comment included as Exhibit 2 a "List of Errors Found in both appendix M and appendix M1" ("AHRI Exhibit 2", EERE-2017-BT-STD-0062-0117 at

[4] Waivers granted to GD Midea Heating and Ventilating Equipment Co., Ltd. (83 FR 56065), Johnson Controls, Inc. (83 FR 12735 and 84 FR 52489), and TCL Air Conditioner (Zhongshan) Co., Ltd. (84 FR 11941);, interim waivers granted to National Comfort Products, Inc. (83 FR 24754), Aerosys Inc. (83 FR 24762), LG Electronics U.S.A., Inc. (85 FR 40272), and Goodman Manufacturing Company, L.P. (86 FR 40534).

pp. 23-24). Many of the errors pointed out by AHRI regard typographical errors in appendix M and appendix M1. DOE is addressing these issues in this rulemaking.

C. Deviation from Appendix A

In accordance with section 3(a) of 10 CFR part 430, subpart C, appendix A ("Appendix A"), DOE notes that it is deviating from the provision in appendix A regarding the early assessment process prior to the NOPR stage to notify stakeholders that DOE is considering a rulemaking to amend a test procedure and solicit comment on whether an amended test procedure would more accurately measure energy efficiency, energy use, water use (as specified in EPCA), or estimated annual operating cost of a covered product during a representative average use cycle or period of use without being unduly burdensome to conduct or reduce testing burden. DOE is opting to deviate from this provision by proposing changes to the test procedure in this proposed rule without first having gone through the early assessment process because DOE has already been made aware by stakeholders that the test procedure for CACs/HPs could be enhanced to improve repeatability, representativeness, and accuracy, and reduce testing burden, and the proposals in this document are aimed at addressing those issues. Additionally, resolution of these issues has some urgency because the test procedure the proposals address is required to be used for testing starting on January 1, 2023. Hence, because DOE is aware that the test procedure could be improved to be more repeatable and representative, and less burdensome, a general early assessment process of request of comments, data, and information prior to the NOPR stage is not considered necessary.

II. Synopsis of the Notice of Proposed Rulemaking

In this notice of proposed rulemaking ("NOPR"), DOE proposes to update appendix M1 to subpart B of part 430, "Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps." DOE has identified certain provisions of appendix M1 that may benefit from additional detail and/or instruction. The proposed updates are as follows:

(1) Adjusting the default fan power for two-stage coil-only systems when testing at low stage with reduced air volume rate to be more representative of fan input power trends as air volume rate reduces;

(2) Defining "Variable-speed Communicating Coil-only Central Air Conditioner or Heat Pump" and "Variable-speed Non-communicating Coil-only Central Air Conditioner or Heat Pump" and establishing procedures specific for testing such systems;

(3) Allowing the adjustment of the air volume rate as a function of outdoor air temperature during testing for blower coil systems with either multiple-speed or variable-speed indoor fans and with a control system capable of adjusting air volume rate as function of outdoor air temperature;

(4) Adjusting the maximum wet bulb temperature from 3°F to 4°F for the H4 test condition;

(5) Specifying in section 2(B) of appendix M1, that the instructions presented in the labels attached to the unit take precedence over the installation manuals printed and shipped with a product;

(6) Specifying in sections 3.1.4.1.1, 3.1.4.1.2, and 3.1.4.4.3 of appendix M1 that the airflow measurement apparatus fan must be adjusted if necessary to maintain the same air volume rate for different test conditions for systems not including multiple-speed or variable-speed indoor fans with control system capability to adjust air volume rate as function of operating conditions such as outdoor air temperature; and

(7) Revising the equations representing full-capacity operation of variable-speed heat pumps at and above 45 ºF ambient temperature to be consistent with the intent for nominal capacity operation.

Additionally, in this notice of proposed rulemaking ("NOPR"), DOE proposes to update 10 CFR part 429, "Certification, Compliance, and Enforcement for Consumer Products and Commercial and Industrial Equipment". DOE has identified certain provisions of part 429 that may benefit from additional detail and/or instruction. The proposed updates are as follows:

(1) Clarifying the language for required represented values for single-stage and two-stage coil-only CACs; and

(2) Providing additional direction regarding the regional standard requirements in part 429.

DOE's proposed substantive actions are summarized in Table II.1 compared to the current test procedure as well as the reason for the proposed change ("attribution"). Additional proposed incidental changes are summarized in Tables III-2 and III-3 in section III.C.10 of this document.

Table II-1 Summary of Changes in Proposed Test Procedure Relative to Current Test Procedure

Current DOE Test Procedure	Proposed Test Procedure	Attribution
Calculate indoor fan power of two-stage coil-only CACs and HPs using constant default fan power values that do not vary with air volume rate (441W/1000 scfm for most two-stage coil-only CACs and HPs and 406 W/1000 scfm for mobile-home and space-constrained CACs and HPs).	Calculate indoor fan power of two-stage coil-only CACs and HPs for reduced air volume rate tests using new default fan power values air volume rate (360 W/1000 scfm for most two-stage coil-only CACs and HPs and 331 W/1000 scfm for mobile-home and space-constrained CACs and HPs).	Improve representativeness.
No test procedure provisions for variable-speed, coil-only CACs and HPs.	Test procedures and requirements established for variable-speed coil-only systems, include new definitions for "Variable-speed Communicating Coil-only Central Air Conditioner or Heat Pump" and "Variable-speed Non-communicating Coil-only Central Air Conditioner or Heat Pump", for which the newly established test procedures have more flexibility.	Incorporate test procedures contained in test procedure waivers.
Appendix M1 currently does not explicitly allow for variation of air volume rate as outdoor temperature changes when testing blower coil systems.	For blower coil systems with multiple-speed or variable-speed indoor fans and the control system capability to adjust air volume rate as a function of outdoor air temperature, allow such air volume rate variation during testing.	Improve representativeness for certain models.
Appendix M1 contains provisions for conducting an optional H4 heating test at a 5°F outdoor ambient dry-bulb temperature and, at a maximum, a 3°F outdoor wet-bulb temperature	Amend the wet bulb test condition for the H4 test to be 4°F maximum instead of the current condition of 3°F maximum	Reduce test burden by reducing the time needed to remove sufficient moisture to achieve the wet bulb requirement.
Clarification regarding which form of installation instructions to use, if multiple forms are provided, only for VRF multisplit systems.	Add direction to prioritize the instructions presented in the label attached to the unit over the installation instructions shipped with the unit for all CAC/HP products.	Improve representativeness and repeatability.
Appendix M1 currently is not clear about how to achieve the same air volume rate for different test conditions.	Add specific instruction to adjust the airflow measurement apparatus fan but not the fan of the unit under test to achieve the same air volume rate for different tests.	Improve representativeness and repeatability.
The equations for full-capacity operation for variable-speed heat pumps at and above 45 ºF ambient temperature are based on operating in this range with a compressor speed the same as its operation in 17 ºF ambient temperature.	Revise the equations for full-capacity operation at and above 45 ºF to be more consistent with compressor speed used in normal operation for this temperature range, represented by the nominal heating test condition, $H1_N$.	Improve representativeness.
10 CFR part 429 provides requirements regarding regional CAC/HP efficiency standards.	Reinforce the language explaining regional requirements.	Improve clarity.

Current DOE Test Procedure	Proposed Test Procedure	Attribution
10 CFR 429.16(a)(1) provides requirements for represented values of single-stage and two-stage coil-only CACs that can lead to different interpretation	Modify the instructions in that section to improve clarity without changing meaning	Improve repeatability.
10 CFR 430.2 defines central air conditioner, excluding two commercial package air-conditioning and heating categories--packaged terminal air conditioners and packaged terminal heat pumps	Add exclusions for additional commercial package air-conditioning and heating categories that justifiably are not central air conditioners	Improved representativeness

As mentioned previously, DOE is also fixing typographical errors in appendix M and appendix M1 that were commented upon by AHRI. DOE is addressing these issues in this rulemaking.

Under 42 U.S.C. 6293(e)(1), DOE is required to determine whether an amended test procedure will alter the measured energy use of any covered product. If an amended test procedure does alter measured energy use, DOE is required to make a corresponding adjustment to the applicable energy conservation standard to ensure that minimally compliant covered products remain compliant. (42 U.S.C. 6293(e)(2)) DOE has tentatively determined that the proposed amendments described in section III of this NOPR would not alter the measured efficiency of CAC/HPs that are rated using the test procedure that is currently required for testing, i.e. appendix M. The proposals applicable for appendix M are simply fixing errors within the current test procedure. With respect to appendix M1, many of the proposals clarify test procedures rather than making changes that would affect the measurements. Variable-speed coil-only systems are not addressed currently in appendix M, so this proposal is establishing a method of test for those products. For two-stage coil-only systems, DOE is proposing to adjust the fan power to be more representative as further described in section X, which DOE believes will slightly improve the measured efficient of these combinations as compared to their current representative values. Given that two-sage combinations are not representative of minimally compliant combinations, DOE has tentatively determined that this proposal would not require an adjustment to the energy conservation standard for central air conditioners and heat pumps to ensure that minimally compliant central air conditioners and heat pumps would remain compliant. Additionally, DOE has tentatively determined that the proposed amendments, if made final, would not increase the cost of testing. Discussion of DOE's proposed actions are addressed in detail in section III of this NOPR.

III. Discussion

A. Scope of Applicability

DOE is proposing to amend the test procedures at appendix M1 for CAC/HP and to implement a few minor clerical revisions to the test procedures at appendix M. A *Central air conditioner or central air conditioner heat pump* is defined as a product, other than a packaged terminal air conditioner or packaged terminal heat pump, which is powered by single phase electric current, air cooled, rated below 65,000 British thermal units per hour ("Btu/h"), not contained within the same cabinet as a furnace, the rated capacity of which is above 225,000 Btu/h, and is a heat pump or a cooling unit only. A central air conditioner or central air conditioning heat pump may consist of: A single-package unit; an outdoor unit and one or more indoor units; an indoor unit only; or an outdoor unit with no match. In the case of an indoor unit only or an outdoor unit with no match, the unit *must* be tested and rated as a system (combination of both an indoor and an outdoor unit). 10 CFR 430.2.

Appendix M1applies to the following CACs/HPs:

(a) Split-system air conditioners, including single-split, multi-head mini-split, multi- split (including VRF), and multi-circuit systems;

(b) Split-system heat pumps, including single-split, multi-head mini-split, multi-split (including VRF), and multi-circuit systems;

(c) Single-package air conditioners;

(d) Single-package heat pumps;

(e) Small-duct, high-velocity systems (including VRF);

(f) Space-constrained products—air conditioners; and

(g) Space-constrained products—heat pumps.

See Section 1.1 of appendix M1.

DOE is not proposing to change the scope of CACs/HPs covered by appendix M1.

B. Topics Arising from Test Procedure Waivers

1. Fan Power at Reduced Airflows for Coil-Only Systems

Coil-only systems are indoor units that are distributed in commerce without an indoor blower or separate designated air mover. Such systems installed in the field rely on a separately installed furnace or a modular blower for indoor air movement. Because coil-only CAC/HPs do not include their own indoor fan to circulate air, the DOE test procedures prescribe equations that are used to calculate the assumed (*i.e.*, "default") power input and heat output of an average furnace fan with which the test procedure assumes the indoor coil is pared in a field installation. The resulting fan power input value is added to the electrical power consumption measured during testing. The resulting fan heat output value is subtracted from the measured cooling capacity of the CAC/HP for cooling mode tests and added to the measured heating capacity for heating mode tests. In appendix M1, separate fan power and fan heat equations are provided for different types of coil-only systems (*i.e.*, the equations for mobile home or space-constrained are different than for "conventional" non-mobile home and non-space-constrained). In each equation, the measured airflow rate (in cubic feet per minute of standard air ("scfm")) is multiplied by a defined coefficient (expressed in Watts ("W") per 1,000 scfm ("W/1000 scfm") for fan power, and British Thermal Units ("Btu") per hour ("Btu/h") per 1000 scfm ("Btu/h/1000 scfm") for fan heat), hereafter referred to as the "default fan power coefficient" and "default fan heat coefficient".

In appendix M, the default fan power coefficient is defined as 365 W/1000 scfm, and the default fan heat coefficient is defined as 1,250 Btu/h/1000 scfm.[5] (appendix M, section 3.3.d). For testing of two-stage coil-only systems, appendix M requires testing at two load conditions: (1) full-load, operating at full compressor stage, and (2) low-load (also referred to as part-load), operating at the lower compressor stage. The test procedure defines the relative air volume rates to use for each test; in general, the part-load test has a lower air volume rate than the full-load test.[6] For both the default fan power coefficient and default fan heat coefficient, the same coefficient is used for both the full-load and part-load tests.[7]

The January 2017 Final Rule adopted certain values in appendix M1 to be more representative of field conditions, as compared to appendix M (*i.e.*, consistent with indoor fan power consumption at the increased minimum required external static pressures defined in appendix M1). 82 FR 1426, 1451-1453. Specifically, appendix M1 defines separate default fan power coefficients and default fan heat coefficients for coil-only systems intended for installation in mobile-home applications and for space-constrained systems, as opposed to those intended for all other "conventional" applications. *Id.*

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[5] For example, for a CAC/HP test conducted at an airflow rate of 1640scfm, the default fan power would be calculated as (365 W/1000scfm × 1640 scfm = 599W); and the default fan heat would be calculated as (1,250 Btu/1000scfmh × 1640 scfm = 2050 Btu/h).

[6] Specifically, the indoor air volume rate to be used for testing at part-load (*i.e.*, the "cooling minimum air volume rate") is the higher of (1) the rate specified by the installation instructions included with the unit by the manufacturer, or (2) 75 percent of the cooling full-load air volume rate (see section 3.1.4.2.c of appendix M)

[7] For example, for a two-stage coil-only system that has a cooling full-load air volume rate of 1640 scfm and a cooling minimum (*i.e.*, part-load) air volume rate of 1,230, the default fan power at full load would be calculated as (365 W/1000scfm × 1640 scfm = 599 W); and default fan power at part-load would be calculated as (365 W/1000scfm × 1230 scfm = 449 W).

Specifically, for coil-only units installed in mobile-home and space-constrained systems, appendix M1 defines a default fan power coefficient of 406 W/1000scfm and a default fan heat coefficient of 1,385 Btu/h/1000 scfm. For coil-only units installed in conventional (*i.e.*, non-mobile-home and non-space-constrained) systems, appendix M1 defines a default fan power coefficient of 441 W/1000 scfm and a default fan heat coefficient of 1,505 Btu/h/1000 scfm. (10 CFR part 430, subpart B, appendix M1, section 3.3.d). As with appendix M, in appendix M1, for both the default fan power coefficient and default fan heat coefficient, the same coefficient is used for both the full-load and part-load tests.

In updating the default fan power coefficients and default fan heat coefficients for coil-only systems in appendix M1, DOE relied on indoor fan electrical power consumption data collected from product literature, testing, and exchanges with manufacturers during a previous furnace fan rulemaking (see 79 FR 500, 506; Jan. 3, 2014) to determine appropriate values for these coefficients for coil-only products. 80 FR 69277, 69318.

By letter dated September 7, 2021, Nortek filed a petition for waiver and interim waiver from the test procedure for CAC/HPs set forth in appendix M1.[8] Specifically, Nortek requested waivers for basic models of ducted, coil-only, two-stage CAC/HPs. Nortek asserted that appendix M1 contains errors in the calculations for capacity adjustment and power consumption for the indoor fan at part-load conditions resulting from a faulty assumption of default fan wattage at reduced airflows. (Nortek, EERE-2021-BT-WAV-0025, No. 1 at p. 1) Nortek asserted that by applying the same default fan power coefficient and default fan heat coefficient to both the full-load and part-load

[8] As noted, appendix M1 is the test procedure applicable to CAC/HPs beginning January 1, 2023.

tests, appendix M1 incorrectly establishes a linear relationship between indoor airflow and fan power (and fan heat); whereas, according to Nortek, a cubic relationship should be applied instead, citing the theoretical fan affinity laws that describe the relationship between fan power and airflow. (Nortek, EERE-2021-BT-WAV-0025, No. 1 at p. 2) Nortek recommended an alternate test procedure that would define lower default fan power coefficients and default fan heat coefficients for the part-load tests, instead of applying the same coefficients to both the full-load and part-load tests, as is done in appendix M1. (Nortek, EERE-2021-BT-WAV-0025, No. 1 at pp. 4-9)

On November 16, 2021, DOE published a notification that announced its receipt of the petition for waiver and denial of Nortek's petition for an interim waiver. 86 FR 63357 ("Notification of Petition for Waiver"). In the Notification of Petition for Waiver, DOE noted that applying the modified default fan power coefficients and default fan heat coefficients in appendix M1 to products such as those that are the subject of Nortek's petition was determined to be representative of the systems' performance and reflected the adoption of the recommendations of a working group formed to negotiate a notice of proposed rulemaking for energy conservation standards for CAC/HPs; and that the modified coefficients were subject to public comment during the 2016 test procedure rulemaking for CAC/HPs. 82 FR 1426, 1452 (January 5, 2017). DOE also noted that Nortek commented in support of the modified coefficients during the 2016 rulemaking. *Id*.

In response to the issue raised by Nortek, DOE re-examined the furnace fan electrical power consumption data collected for the furnace fans rulemaking (see 79 FR 506, Jan. 3, 2014) that was used to develop the default fan power coefficients and default fan heat coefficients for coil-only products in appendix M1. In establishing the current coefficients, for each furnace fan in DOE's furnace fan dataset, DOE developed correlations of airflow and power consumption as functions of external static pressure ("ESP"), and then applied those correlations to a reference ductwork system curve to predict the actual operating airflow and power consumption at each fan speed setting for the furnace fan.

DOE has extended the prior analysis to examine both full-load and part-load air volume rates.[9] DOE correlated the predicted power consumption with the predicted air volume rate for each furnace fan to determine adjusted values of the default fan power coefficients that may result in a more representative estimate of fan power and fan heat at reduced airflow conditions, compared to the coefficients currently defined in appendix M1. DOE's analysis indicates that at a reduced air volume rate of 75 percent, the average indoor fan power coefficient would be 360 W/1000 scfm for coil-only CAC/HPs in a conventional (*i.e.*, non-mobile-home and non-space-constrained) installation. For mobile-home and space-constrained systems, to the average indoor fan power coefficient would be 331 W/1000 scfm. DOE also calculated the associated fan heat coefficients associated with these power input levels. The average indoor fan heat coefficients would be 1,228 Btu/hr/1000 scfm and 1,130 Btu/h/1000 scfm for conventional (*i.e.*, non-mobile-home and non-space-constrained) and mobile-home/space-constrained installations, respectively.

The analysis conducted by DOE resulted in higher default fan power coefficients and default fan heat coefficients at the reduced 75 percent air volume rate than the values presented in the Nortek waiver petition. DOE tentatively concludes that its analysis is a

[9] To ensure consistency across analyses, DOE aggregated the data by applying market weightings to each type and brand of furnace model, using the same market shares that were used in the previous analysis for the 2016 CAC TP Rulemaking.

more appropriate representation of average furnace fan power consumption than the results presented by Nortek for the following reasons: (1) DOE's analysis relied on test and specification data from a collection of actual furnaces operating at reduced air volume rates, whereas the Nortek analysis derived default fan power values using a theoretical relationship between full-load and part-load conditions; (2) DOE's analysis applied the same weighting factors that were used to develop the full-load default values during the 2016 CAC TP Rulemaking, whereas Nortek's analysis introduced new weighting factors and motor efficiency data without indicating the source of the data; and (3) DOE's analysis considered performance data from an additional type of fan motor not considered by Nortek (specifically, constant-torque brushless-permanent-magnet "X13" motors). Therefore, in this NOPR DOE proposes to amend the default fan power coefficients and default fan heat coefficients for coil-only fan power when operating at reduced air volume rates to reflect the results of its analysis. Specifically, when operating at 75 percent air volume rate (or higher manufacturer-specified air volume rate that is between the 75 percent air volume rate and the full-load air volume rate as described in appendix M1, section 3.1.4.2.c), DOE proposes to specify for ducted two-capacity coil-only systems a default fan power coefficient of 360 W/1000 scfm and a default fan heat coefficient of 1,228 Btu/h/1000 scfm for units installed in conventional systems; and a default fan power coefficient of 331 W/1000 scfm and a default fan heat coefficient of 1,130 Btu/h/1000 scfm for mobile home and space-constrained systems.[10]

The reduced air volume rate used for low-stage operation of two-stage coil-only systems may be higher than 75 percent of the full-load air volume rate, if the

[10] For example, under DOE's proposed changes to Appendix M1, for a two-stage coil-only system in a conventional application that has a cooling full-load air volume rate of 1640 scfm and a cooling minimum (*i.e.*, part-load) air volume rate of 1,230, the default fan power at full load would be calculated as (441 W/1000scfm × 1640 scfm = 723 W); and default fan power at part-load would be calculated as (371 W/1000scfm × 1230 scfm = 456 W).

manufacturer's instructions specify a higher part-load air volume rate. DOE is proposing that in such cases, the default fan power values associated with full-load air volume rate be used. However, the appropriate default fan power coefficient and default fan heat coefficient may be values between the reduced values discussed above and the values used for full-load air volume rate. For such cases, DOE could consider alternative options, other than requiring use of the full-load air volume default fan power and fan heat coefficients. Two alternative options include (1) allowing the reduced value up to a threshold value, e.g. 80 percent of full-load air volume rate, above which the full-load value would be required, and (2) requiring a linear interpolation of the default fan power coefficient between the reduced value at 75 percent of full-load air volume rate to the full-load value at 100 percent.[11] DOE seeks comment on whether one these alternate approaches should be adopted instead of the proposed use of the single reduced coefficients for the category discussed previously.

DOE requests comment on its proposal to specify a reduced default fan power coefficient and default fan heat coefficient at part-load airflows in the calculations of SEER2 and HSPF2 for ducted two-stage coil-only systems. DOE requests comment on the specific default fan power coefficients and default fan heat coefficients proposed. If the proposed values are not appropriate, DOE seeks data to support selection of alternative values. Additionally, DOE requests comment on whether a single default fan power coefficient (and default fan heat coefficient) should be used for each product class group regardless of the actual air volume rate used for low-stage tests, or whether one of the alternative approaches discussed in the NOPR should be considered, or any other alternative. DOE also requests comment on whether any two-stage systems use a part-

[11] For example, for non-mobile-home and non-space-constrained systems, if a linear interpolation of the default fan power coefficient is required, it would be equal to 371 + (441 – 371)*(%FLAVR – 75%)/(100% - 75%), where %FLAVR is the reduced air volume rate used for the test expressed as a percentage of the full load air volume rate.

load air volume rate higher than 75 percent of the full-load air volume rate, and if so, whether the ratio is a value less than 100 percent.

2. Variable-Speed Coil-Only Test Procedure

As discussed, appendix M1 contains provisions for testing split-system CAC/HPs equipped with "coil only" indoor units that, in a field installation, are paired with an existing furnace or other air handler in order to circulate conditioned air through ductwork. These provisions apply to single-stage and two-stage systems.[12] appendix M1 does not include provisions for testing variable-speed systems equipped with coil-only indoor units.

Since the publication of the January 2017 Final Rule, DOE has granted test procedure waivers to GD Midea Heating & Ventilating Equipment Co., Ltd. ("GD Midea") (83 FR 56065 (Nov. 9, 2018)) and TCL air conditioner (zhongshan) Co. Ltd. ("TCL AC") (84 FR 11941 (Mar. 29, 2019)), and an interim waiver for LG Electronics U.S.A., Inc. ("LGE") (85 FR 40272 (July 6, 2020)), for specified basic models of variable-speed, coil-only CAC/HPs. In each of these cases, the petitioners identified their variable-speed coil only systems as "non-communicative" systems for which compressor speed varies based only on controls located on the outdoor unit, and for which the indoor unit maintains a constant indoor blower fan speed (see, e.g., 83 FR 24767, 24769 (May 30, 2018)). As required under the specified alternate test procedures, the subject systems must be tested according to the appendix M provisions applicable to variable-speed systems (e.g., three different compressor speeds in the cooling mode), except that the

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[12] Section 3.1.4.2 (cooling minimum air volume rate), section 3.1.4.3 (cooling intermediate air volume rate), and section 3.1.4.6 (heating intermediate air volume rate) of appendix M1

subject systems must be tested using the full-load cooling air volume rate at all test conditions, commensurate with the constant indoor blower fan speed that these units would experience (GD Midea, EERE-2017-BT-WAV-0060, No. 1, pp. 1-3; TCL, EERE-2018-BT-WAV-0013, No. 1, pp. 2-4; LG, EERE-2019-BT-WAV-0023, No. 1, pp 3-4). DOE notes that the waivers for these models were granted for appendix M only and will expire on Jan 1, 2023 – the date when use of appendix M1 becomes required for any representations, including compliance certifications, made with respect to the energy use, power, or efficiency of CAC/HPs.

DOE notes also that the waivers for "non-communicative" variable-speed coil-only systems did not address comprehensively how the outdoor units are controlled to turn on or off in cooling mode or in heating mode, nor how the compressor speeds are set to match the internal building load. Regarding the latter, the waivers indicated only that "compressor speed varies based only on controls located on the outdoor unit" (GD Midea, EERE-2017-BT-WAV-0060, No. 1, p. 6; TCL, EERE-2018-BT-WAV-0013, No. 1, p. 4; LG, EERE-2019-BT-WAV-0023, No. 1, pp 2). DOE did not receive information in the waiver petitions regarding, nor has it evaluated, the compressor speed selections used for different test conditions specified in appendix M or appendix M1. Further, DOE has not compared these speed selections with those used by blower-coil variable speed systems for the same test conditions. Based on the information received and evaluated, DOE has yet to receive sufficient evidence that can be relied on to conclude that the alternate test procedures specified in the waivers are representative of average use cycles of CAC/HPs other than those subject to the granted waivers, as required by EPCA for DOE test procedures.

DOE has also granted an interim test procedure waiver to Goodman Manufacturing Company, L.P. ("Goodman") (86 FR 40534 (July 28, 2021)) for their basic models of variable-speed, coil-only CAC/HPs. Unlike the aforementioned test procedure waivers, Goodman represented, and supported in their petition, that their systems have communicative controls, where both the outdoor unit and indoor coil communicate with each other to control both the variable-speed compressor and multi-speed indoor fan. 86 FR 40534, 40539. As a result, the alternate test procedure prescribed under the interim waiver requires use of two different indoor air volume rates during testing to simulate the impacts of communicative control that would be realized in a typical field installation. 86 FR 40534, 40538. Specifically, the Goodman waiver requires use of the cooling full-load air volume rate for the full-load cooling and full-load heating tests; and the cooling minimum air volume rate for the cooling minimum, heating minimum, cooling intermediate, and heating intermediate tests. *Id.*

In response to the notice of petition for waiver, Rheem questioned the approach of the alternate test procedure in specifying two different indoor air volume rates during testing of these basic models. (Rheem, EERE-2021-BT-WAV-0001, No. 7 at p. 1). Rheem expressed concern that the alternate test procedure would allow Goodman an unfair competitive advantage, (*i.e.,* by allowing reduced airflow rates at low-load test conditions while other variable-speed coil-only products would be required to test at full-load cooling air volume rate for all test conditions), that it would be unlikely that installers would correctly install the communicative products to enable the indoor fan control requested in Goodman's proposed alternate test procedure, and that most furnace fans currently installed are not capable of adding controls to set multiple airflow rates. In response to the Rheem comment, Goodman stated that almost all two-stage coil-only ratings today utilize a lower indoor air volume rate for low-stage compressor operation, and highlighted training procedures and other best-practices put in place to ensure proper installation of communicating systems. (Goodman, EERE-2021-BT-WAV-0001, No. 8 at pp. 1-4)

As stated in a final rule published in 2005, use of a lower air volume rate for low-stage operation is based on the assumption that the two-capacity coil-only unit would most often be used with an existing multi-tap furnace blower (*i.e.,* a furnace fan capable of multiple speeds). 70 FR 59122, 59128 (October 11, 2005). The two-stage coil-only test provisions in the DOE test procedure are premised on the installation location having two-stage thermostat wiring (Final Rule Technical Supporting Document, EERE-2014-BT-STD-0048, No. 98, p. 8-25). DOE similarly assumes the presence of the necessary wiring for the installation of variable-speed systems.

As mentioned in the notification of the interim waiver issued in response to the Goodman petition, DOE reviewed numerous materials relevant to the control of the Goodman variable-speed coil-only system, including additional materials Goodman provided in support of the petition. 86 FR 40534, 40537 (July 28, 2021). These materials included installation manuals and other information that confirmed similarities between the system's control and the control of more conventional variable-speed blower-coil systems (including the use of communicating controls), providing justification for claims that the alternate test procedure specified in the waiver would be representative of average use.

DOE notes that Goodman's interim waiver was granted for both appendix M and appendix M1. The waiver for appendix M will expire on the date representations are required to be based on testing according to appendix M1 (Jan 1, 2023), and the waiver for appendix M1 will expire on the date on which use of an amended test procedure that addresses the issues presented in the Goodman waiver is required to demonstrate compliance. 10 CFR 430.27(h)(3).

In this NOPR, DOE proposes to add testing provisions addressing variable-speed coil-only systems in appendix M1. DOE also proposes to define "communicating control" in the context of variable-speed, coil-only CAC/HPs in order to differentiate between the test procedure provisions that would be applicable to communicating systems from those applicable to non-communicating systems.

DOE is proposing provisions as generally prescribed in the relevant waivers, except that DOE is proposing to require that all variable-speed coil-only systems, regardless of communicative capability, would be tested using the cooling minimum air volume rate for the cooling minimum, heating minimum, cooling intermediate, and heating intermediate tests. This proposal is consistent with the conditions specified in the interim waiver granted to Goodman. DOE further proposes to require that non-communicative variable-speed coil-only systems be tested using the newly proposed provisions for variable-speed compressor with non-communicating coil-only systems (*i.e.*, eliminating the E_V test for cooling and $H2_V$ for heating as well as including $H2_2$, $H2_1$ and $H3_1$ for heating), whereas systems that meet the newly proposed criteria for "communicating" control would follow the existing variable-speed test procedure.

Regarding indoor air volume rate, the proposed test procedure would utilize the same procedure as for ducted two-capacity coil-only units. As discussed previously, the two-stage coil-only test procedure is premised on the capability of controlling an existing multi-tap furnace fan at two air volume rates for cooling operation. DOE is not proposing to amend this approach. DOE is proposing to apply a similar approach to the testing of variable-speed coil-only systems. As such, DOE proposes to align the requirements for minimum air volume rate between two-capacity and variable-speed coil-only indoor units, regardless of communicating capabilities. This includes adopting the reduced default fan power and default fan heat coefficients at reduced air volume rates discussed in section I.B.1. However, if the system does not include the capability to control an existing furnace fan at two air volume rates, the manufacturer has the option of specifying minimum/intermediate air volume rates equal to the full-load air volume rate. Regarding compressor speed, the proposed test procedure would limit use of the variable-speed testing provisions to those systems meeting the newly proposed criteria for communicating control.

As previously stated, the test procedure for two-stage coil-only systems is premised on the system using a two-stage thermostat and associated wiring that responds to indoor temperature measurements and sends voltage signals that enable two-stage control of both the compressor speed and the indoor fan speed. A more sophisticated control approach is required to enable a variable speed system to modulate compressor speed control (*e.g.*, proprietary thermostat, serial communication wiring, and/or electronic sensors at the indoor coil). DOE proposes to define “Communicating Variable-speed Coil-only Central Air Conditioner or Heat Pump” in section 1.2 of appendix M1 to distinguish variable-speed coil-only systems with such control as the following:

Variable-Speed Communicating Coil-Only Central Air Conditioner or Heat Pump means a variable-speed compressor system having a coil-only indoor unit that is installed with a control system that (a) communicates the difference in space temperature and space setpoint temperature (not a setpoint value inferred from on/off thermostat signals) to the control that sets compressor speed; (b) provides a signal to the indoor fan to set fan speed appropriate for compressor staging and air volume rate; and (c) has installation instructions indicating that the required control system meeting both (a) and (b) must be installed.

DOE also proposes to define variable-speed systems that do not have this communicating feature as the following:

Variable-Speed Non-communicating Coil-Only Central Air Conditioner or Heat Pump means a variable-speed compressor system having a coil-only indoor unit that does not meet the definition of variable-speed communicating coil-only central air conditioner or heat pump.

Variable-speed coil-only systems that meet the "communicating" definition would be tested like any other variable-speed system, except that the heating full-load air volume rate would be equal to the cooling full-load air volume rate, and the intermediate and minimum cooling and heating air volume rates would all be the higher of (1) the rate specified by the installation instructions included with the unit by the manufacturer, and (2) 75 percent of the full-load cooling air volume rate.

DOE proposes that those variable-speed coil-only systems that are not "communicating" as defined above would be tested with additional limitations as if they have some variable-speed system characteristics and some two-stage coil-only system characteristics. Specifically, (a) the outdoor unit and/or the indoor unit would be provided with a control signal indicating operation at high or low stage, rather than testing with compressor speed fixed at specified speeds, and (b) air volume rates would be determined consistent with the requirement for two-stage coil-only systems. A key implication of (a) is that there would be no intermediate compressor speed operation. Many of the requirements associated with variable-speed operation would, however, be retained. For example, such systems would be allowed to have “minimum speed-limiting” control for heat pump mode (see the alternative calculations representing minimum-speed operation in appendix M1, section 4.2.4.b). The test method for non-communicating variable-speed coil-only systems would include requiring tests for minimum-speed operation for both the 35 ºF and 17 ºF heating test conditions so that the HSPF2 calculations utilize test results for appropriate compressor speeds. Also, the full compressor speed during heating mode operation would be allowed to vary with outdoor temperature, there would be an $H1_N$ test to represent the nominal capacity, and the same provisions for calculation of full-speed capacity and power applied to conventional variable-speed systems would be used (see, e.g., the calculations in appendix M1, sections 3.6.4, 4.2.4.c, and 4.2.4.d). If a manufacturer chooses to run the optional $H1_2$ test (i.e. if compressor speed for the $H1_N$ test is different than compressor speed for the $H3_2$ test, and the manufacturer chooses to run the $H1_2$ test rather than use the standardized slope factors described in appendix M1 section 3.6.4.b), then the test would be run with over-ride of compressor speed using the same speed as used for the $H3_2$ test--this is the only test for which such over-ride would be allowed.

To ensure consistency of testing, it may be necessary for manufacturers to certify whether a variable-speed coil-only rating is based on non-communicating or communicating control. However, this change is not being proposed in this NOPR and may be considered in a separate rulemaking.

DOE requests comment on its proposals related to test procedures for variable-speed coil-only CAC/HPs and on its proposed definitions for variable-speed communicating and non-communicating coil-only CAC/HPs.

DOE recognizes that there may be variable-speed control technology that cannot be tested according to the proposed test approach described previously for non-communicating variable-speed coil-only systems. Specifically, the test approach may not result in tests that meet the stability requirements for testing (*i.e.*, the measurements might not meet the tolerance requirements in Table 2 of ANSI/ASHRAE 37-2009, "Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment," ("ASHRAE 37-2009"), which is incorporated by reference by the DOE test procedure). Or the proposed test procedure might evaluate such a basic model in a manner so unrepresentative of its true energy consumption characteristics as to provide materially inaccurate comparative data. In this case, the manufacturer may petition DOE for a waiver and include a suggested alternate test procedure. See 10 CFR 430.27. As part of its review of such a waiver and alternate test procedure, DOE would consider the correlation between results of a suggested alternate test procedure and results of testing when using the two-stage two-wire controls expected to be available in a general coil-only system installation, recognizing that the latter testing may involve dynamics that exceed the measurement tolerances discussed above. DOE would also consider the control hardware involved in achieving appropriate control for indoor and outdoor conditions and some understanding of how the control works.

DOE is aware that installations using non-communicating controls may not be limited only to variable-speed coil-only systems, but could also occur with variable-speed blower-coil systems. DOE's proposal makes a distinction between the testing approach used for coil-only configurations and the testing approach used for blower-coil configurations. As coil-only installations are much more likely than blower-coil installations to involve use of both the existing furnace fan and existing controls, the test procedure should be reflective of coil-only installations because they are more representative than blower coil installations.

DOE has considered whether the current test procedures for variable-speed systems generally give manufacturers too much flexibility in specifying fixed settings of the compressor and indoor fan for testing without requiring the selected settings to be demonstrated using native control testing. DOE is well aware that there is ongoing work addressing questions about whether the current DOE test procedure for variable-speed systems is fully representative of native control operation. However, DOE has initiated this rulemaking not as a comprehensive revision that will satisfy the 7-year lookback requirements (see 42 U.S.C. 6293(b)(1)(A)), but instead as an action that will address a focused group of known issues, including those that have been raised through the test procedure waiver process. Thus, DOE is limiting its proposals addressing potential concerns about variable-speed systems to coil-only systems, for which there are clear differences in system controls architecture, particularly when using non-communicating controls, which impact the performance of these systems in the field. However, DOE may more comprehensively address these issues for all variable-speed systems in a future rulemaking.

Coil-Only Variable-Speed System Representations and Testing

Coil-only testing approaches for variable-speed systems address the installation of variable-speed technology in which the newly-installed system uses existing components, for example an existing furnace fan. For single-capacity and two-capacity air-conditioners, certification requirements anticipate this potential gap by requiring that such models include performance representations with a coil-only combination representative of the least-efficient combination in which the outdoor unit is sold (see 10 CFR 429.16(a)(1)). DOE considered whether such a requirement may be appropriate for variable-speed systems.

A review of manufacturing materials, such as product datasheets and installation instructions, indicates that there is a wide range of instruction provided regarding the need to pair a variable-speed outdoor unit with specific models of indoor units and/or air movers (e.g., furnaces) whose controls can be coordinated with those of the outdoor unit to optimize performance. Some literature is very clear that achieving the rated performance requires installation with specific models of mating components with variable-speed indoor fans and communicating controls. However, other models have literature that does not mention the need for such pairing of components. The latter group is not limited to brands that have received test procedure waivers or interim waivers for variable-speed coil-only systems. Thus, it is possible that variable-speed systems are being installed in coil-only applications for which the system representations may not be representative of actual performance because the representations are blower-coil based. Realizing this possibility, DOE considered the approaches that could be applied to address this issue.

Currently, every single-split system AC with other than single-stage and two-stage compressors must represent every individual combination distributed in commerce, including all coil-only and blower coil combinations. 10 CFR 429.16(a)(1). These regulations, when combined with the test procedure proposals in this NOPR, would require manufacturers to represent variable-speed ACs based on how they distribute them in commerce, which includes whether they are coil-only communicating, coil-only noncommunicating, or blower coil, as applicable to a given model of outdoor unit. DOE would evaluate how manufacturers distribute models of outdoor units based on review of product datasheets, installation and operation manuals, product marketing, relevant databases (including the AHRI database), manufacturer websites, and other related materials that help inform the consumer how the outdoor unit should be installed.

As noted previously, representations of efficiency for single-split air conditioners with a single-stage or two-stage compressor must include at least one coil-only combination representative of the least-efficient combination distributed in commerce with that outdoor unit. 10 CFR 429.16(a)(1). As part of this rulemaking, DOE considered adopting such an approach for all single-split outdoor units, including variable speed models, to ensure that representations include all installations that may occur in the field. However, based on the information DOE has from the previous energy conservation standards rulemaking pertaining to central air conditioners and heat pumps, less than 5 percent of variable-speed system installations are coil-only installations. 82 FR 1786. Further, the number of certified combinations of variable-speed coil-only systems is a small percentage of all of the variable-speed system certifications.[13] Based on this information, DOE concludes that installations of variable-speed systems in coil-only applications are not likely to be representative of variable-speed system operation as a whole. For this reason, DOE is not proposing a blanket coil-only representation requirement for variable-speed systems. However, DOE may revisit this possibility if it

[13] For example, there are roughly 27,000 combinations listed in the AHRI Database for which a non-zero intermediate indoor air volume rate is listed, indicating that the combination is a variable-speed model. DOE reviewed the current certifications in the certification compliance management system and found that there are approximately 400 variable-speed coil-only combinations, representing roughly 1.5 percent of the total variable speed combinations certified to the Department.

determines that there is significant distribution in commerce of coil-only variable-speed systems using outdoor units that do not include a coil-only representation.

In order improve representativeness of the representations of variable-speed systems used in coil-only combinations, DOE proposes to require a coil-only tested combination for any variable-speed outdoor unit distributed in commerce in a coil-only combination. In addition, DOE proposes to require that, if a manufacturer distributes in commerce an outdoor unit basic model with other than a single-stage or two-stage compressor in non-communicating coil-only combinations, the combination selected for testing be a non-communicating coil-only combination. If a manufacturer distributes in commerce an outdoor unit basic model with other than a single-stage or two-stage compressor only in communicating coil-only combinations, then the combination selected for testing that outdoor model would be a communicating coil-only combination. Finally, if the manufacturer does not distribute in commerce any coil-only combinations, then the individual combination selected for testing for split-system AC and HP with other than a single-stage or two-stage compressor would be a blower-coil combination.

DOE notes that the variable-speed coil-only waiver petitions addressed both air-conditioners and heat pumps. Thus, DOE's considered whether the coil-only tested combination requirement should apply to variable speed heat pumps and/or to single-stage and/or two-stage heat pumps. DOE notes that coil-only heat pumps allow the heating system to provide heat either using the furnace or the heat pump. There has been greater interest in such systems in recent years, since they provide heating with a furnace in extreme cold conditions for which a heat pump may have limited capacity and/or reduced efficiency.[14] DOE is proposing in this NOPR to require coil-only tested

[14] *https://www.trane.com/residential/en/resources/glossary/dual-fuel-heat-pump/* (last accessed 2/4/2022)

combinations for variable-speed heat pumps, but not for single- and two-stage heat pumps, because DOE expects that the representativeness of blower-coil tests would deviate more from coil-only tests for variable-speed systems, due to the use of a variable-speed indoor fan and use of an intermediate air volume rate used for intermediate-speed testing for variable-speed systems. The test procedures for single-stage and two-stage heat pumps are more restrictive with regard to allowed air volume rates and thus performance differences between blower-coil and coil-only operation would be less.

Regarding variable-speed coil-only systems using indoor units manufactured by independent coil manufacturers ("ICMs"), the regulations require certification of the performance of any variable-speed coil-only combinations distribution in commerce, and whether any given combination is coil-only (see 10 CFR 429.16(a)(1)). However, DOE notes that a tested combination for an ICM indoor unit must include the least-efficient outdoor unit with which the indoor unit is distributed in commerce (see 10 CFR 429.6(b)(2)(i)). DOE does not believe any changes are needed to this proposal with respect to ICM certifications as the current regulations already encompass representing all combinations distributed in commerce, including noncommunicating and communicating variable-speed coil only systems.

DOE requests comment on its approach for variable speed coil-only systems. More specifically, DOE seeks comment on its proposal to require coil-only tested combinations for variable-speed systems, both air-conditioners and heat pumps, that are distributed in commerce with coil-only combinations. DOE also requests comment on the proposal to require that the tested combination be a non-communicating coil-only combination, if the outdoor unit is distributed in commerce in a non-communicating coil-only combination.

3. Space-constrained Coil-only CAC Ratings

DOE's regulations at 10 CFR 429.16 prescribe certification requirements for CAC/HPs. Paragraph (a)(1) of that section includes a table specifying the required represented values for each "tested combination" of CAC/HPs. Table III-1 is an excerpt from the table in 10 CFR 429.16(a)(1) showing represented value requirements for different varieties of split-system CAC/HPs.

Table III-1: Required Represented Values for Split-system CAC/HPs (Excerpted from 429.16(a)(1))

Category	Equipment subcategory	Required represented values
Outdoor Unit and Indoor Unit (Distributed in Commerce by OUM)	Single-Split-System AC with Single-Stage or Two-Stage Compressor (including Space-Constrained and Small-Duct, High Velocity Systems (SDHV))	Every individual combination distributed in commerce must be rated as a coil-only combination. For each model of outdoor unit, this must include at least one coil-only value that is representative of the least efficient combination distributed in commerce with that particular model of outdoor unit. Additional blower-coil representations are allowed for any applicable individual combinations, if distributed in commerce.
	Single-Split-System AC with Other Than Single-Stage or Two-Stage Compressor (including Space-Constrained and SDHV)	Every individual combination distributed in commerce, including all coil-only and blower coil combinations.
	Single-Split-System HP (including Space-Constrained and SDHV)	Every individual combination distributed in commerce.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System - non-SDHV (including Space-Constrained)	For each model of outdoor unit, at a minimum, a non-ducted "tested combination." For any model of outdoor unit also sold with models of ducted indoor units, a ducted "tested combination." When determining represented values on or after January 1, 2023, the ducted "tested combination" must comprise the highest static variety of ducted indoor unit distributed in commerce (i.e., conventional, mid-static, or low-static). Additional representations are allowed, as described in paragraph (c)(3)(i) of this section.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System - SDHV	For each model of outdoor unit, an SDHV "tested combination." Additional representations are allowed, as described in paragraph (c)(3)(ii) of this section.

As presented in Table III-1, single-split CACs with single-stage or two-stage compressors are required to provide represented values for every individual combination distributed in commerce, each rated as a coil-only combination. For each model of outdoor unit, this must include at least one coil-only value that is representative of the least efficient combination distributed in commerce with that model of outdoor unit. Additional blower-coil ratings are allowed (*i.e.,* optional) for any applicable individual combinations, if distributed in commerce. DOE has become aware that these provisions may contain ambiguity over the precise rating requirements for single-split CACs. For example, if the least efficient combination distributed in commerce for a given basic model includes a blower-coil indoor unit (as opposed to the assumption that a coil-only combination would be least efficient), the existing provisions are unclear on which combination would be used to rate the basic model. Accordingly, DOE is proposing to amend the language in the table found in 10 CFR 429.16(a)(1) to clarify the rating requirements pertaining to single-split CACs with single-stage or two-stage compressors.[15]

DOE requests comment on its proposal to clarify the language for required represented values of coil-only CACs found in the table at 10 CFR 429.16(a)(1)

The requirement to provide coil-only ratings for each basic model also applies to single split CACs designed for space-constrained applications ("SC-CAC"). DOE has received three petitions for test procedure waivers related to the represented value requirements for SC-CACs. The first was a petition from National Comfort Products, Inc. ("NCP") dated March 20, 2017 (Docket No. EERE-2017-BT-WAV-0030-0001); the second was a petition from AeroSys, Inc. ("AeroSys") dated May 29, 2017 (Docket No. EERE-2017-BT-WAV-0042-0001); and the third was a petition from First Company ("First Co.") dated May 25, 2018 (Docket No. EERE-2018-BT-WAV-0012-0002). Each

[15] DOE's proposed clarifications would require every single-stage and two-stage outdoor unit of single-split CAC to have a compliant rating with a coil-only combination that is distributed in commerce and representative of the least efficient combination distributed in commerce for that particular model of outdoor unit

petitioner claimed that specified basic models of SC-CAC outdoor units listed in their respective petitions are designed and intended to be sold only with proprietary blower-coil indoor units equipped with high-efficiency electronically commutated ("ECM") fan motors, and not as a coil-only combination (NCP, EERE-2017-BT-WAV-0030, No. 1 at p. 1; AeroSys, EERE-2017-BT-WAV-0042; No. 1 at p. 1, First Co., EERE-2018-BT-WAV-0012, No. 2 at p. 1) Each petitioner also claimed that the identified blower-coil indoor units operate at a much lower wattage than the default fan power required by appendix M for coil-only combinations and asserted that appendix M would not result in a representative rating for the specified basic models (NCP, *Id.* at p. 2; AeroSys, *Id.* at p. 1, First Co., *Id.* at pp. 2-3) Each petitioner requested waivers requiring that the specified basic models be tested according to appendix M and that representations be determined by pairing models only with blower-coil indoor units (*i.e.*, requesting exemption from the requirement in 10 CFR 429.16(a)(1) to provide represented values based on a coil-only combination). (NCP, *Id.* at p. 3; AeroSys, *Id.* at p. 6, First Co., *Id.* at p. 6) These waiver requests were predicated on the premise that the basic models of outdoor units identified by NCP, AeroSys, and First Co. are not intended to be sold with a coil-only indoor unit pairing and are designed to be sold with only the specified blower-coil indoor units containing high-efficiency ECM fans.

In a notice published May 30, 2021, DOE granted AeroSys's petition for interim waiver. Since that time, AeroSys filed for bankruptcy and thus DOE stopped further evaluation of the AeroSys test procedure waiver request.

With respect to First Co.'s petition, DOE has concluded that statements provided in product specification sheets and installation instructions for the subject basic models appear inconsistent with First Co.'s assertion that the subject basic models are distributed in commerce exclusively for use with blower-coil indoor units. For example, installation instructions for affected models include language describing these units as replacements for R-22 systems, and the existing indoor units are unlikely to have the high-efficiency motors used in the described blower-coil indoor units. Additionally, some spec sheets include additional language indicating that installation is intended with existing indoor units that are unlikely to have high efficiency motors.

As NCP's waiver petition and the prescribed alternate test procedure are specific to appendix M, the interim waiver will terminate on the date on which testing is required under appendix M1 (*i.e.*, January 1, 2023); there is no need for continuation of the waiver once testing is required under appendix M1. Moreover, as discussed in the following paragraphs, DOE has tentatively determined that it would be inappropriate to amend appendix M1 to provide for the testing of split-system CACs as requested in the waiver petitions.

DOE is required per EPCA to prescribe test procedures that are reasonably designed to produce test results which measure energy efficiency during a representative average use cycle or period of use, as determined by the Secretary. (42 U.S.C. 6293(b)(3)) For split-system central air conditioner and heat pump outdoor units, determination of what constitutes a representative average use cycle or period of use must include consideration of combinations in which a unit is paired in field installations. DOE published an energy conservation standard final rule to set new standards for central air conditioners and heat pumps on January 6, 2017. 82 FR 1786. In the rulemaking that culminated in this final rule, DOE examined the typical installations for split-system CACs and HPs as part of its assessment of life-cycle costs. DOE determined that 39 percent of split-system CAC installations in 2021[16] would be full-system replacements including a blower-coil indoor unit. Of the 61 percent remaining CAC installations, DOE's determined that 75 percent of these would require replacement of the entire system (*i.e.,* both outdoor unit and coil-only indoor unit) and 25 percent would involve solely replacement of the outdoor unit (*i.e.,* leaving the existing coil-only indoor unit and refrigerant line-sets intact). (Docket No. EERE-2014-BT-STD-0048-0098, p. 8-8).

DOE's analysis indicates that installations involving blower-coil indoor units are in the minority for split-system CACs. While DOE does not have data showing the installation breakdown specifically for space-constrained systems, DOE assumes in the absence of such data that the general installation trends would apply to equally to space-constrained systems. Additionally, DOE has observed instances for which outdoor units designed for space-constrained applications are being distributed in commerce without a corresponding blower-coil indoor unit[17], indicating the potential for pairing a replacement outdoor unit with an existing indoor unit using a legacy fan that would not likely be comparable to the ECM fan of the blower-coil indoor unit on which the system rating is based. DOE notes that the cited example is for sale of an NCP outdoor unit, which indicates that it is impossible to ensure that installations are of systems with blower-coil indoor units, as suggested by NCP's waiver petition.

Consequently, DOE tentatively concludes that measuring the performance of space-constrained systems exclusively with high-efficiency blower-coil combinations, as requested in the NCP, AeroSys, and First Co. waiver petitions, is not generally

[16] DOE based its life-cycle analysis on the assumption that the year of product purchase date would be 2021, which at the time was the assumed effective date of energy conservation standards for CACs and HPs. Accordingly, all installation figures were forecast through the year 2021.
[17] *www.ferguson.com/product/national-comfort-products-3000-series-25-tons-12-seer-r-410a-27200-btuh-room-air-conditioner-nncpe4303010/_/R-4397660*

representative of field operation. Based on this tentative conclusion, amendment to the existing requirements for represented values in 10 CFR 429.16 to allow manufacturers to avoid the coil-only test requirement for single-speed and two-stage space-constrained CACs would provide test results that are not representative of an average use cycle or period of use. DOE is not proposing amendments to appendix M1 regarding the test procedure waiver granted to NCP.

DOE requests comment on its planned approach not to propose waiving the coil-only rating requirement for space-constrained air conditioners and heat pumps. To support any comments suggesting that DOE reverse this decision, DOE requests shipment and/or installation data for space-constrained systems to clarify the characteristics of representative installations.

C. Other Test Procedure Revisions

1. Air Volume Rate Changing with Outdoor Conditions

When testing CAC/HP systems under appendix M1, section 3.1.4 requires determining airflow setting(s) before testing begins; unless otherwise specified, no changes are to be made to the airflow setting(s) after initiation of testing. The subsections of section 3.1.4 provide instructions for establishing air volume rates for the following test conditions: cooling full-load (section 3.1.4.1), cooling minimum (section 3.1.4.2), cooling intermediate (section 3.1.4.3), heating full-load (section 3.1.4.4), heating minimum (section 3.1.4.5), heating intermediate (section 3.1.4.6), and heating nominal (section 3.1.4.7).

For example, section 3.1.4.1.1.a of appendix M1 provides instructions for determining the cooling full-load air volume rate for ducted blower coil systems other than those having a constant-air-volume-rate indoor blower. Within that section, a seven-step process is followed to determine the final fan speed or control settings to be used for testing. Step (7) of the process specifies using the measured air volume rate as the cooling full-load air volume rate, and to use the final fan speed or control settings for all tests that use the cooling full-load air volume rate. Sections 3.1.4.2.a and 3.1.4.4.3.a specify a similar process for determining cooling minimum air volume rate and heating full-load air volume rate, respectively. These sections similarly specify using use the measured air volume rate and final fan speed or control settings for all tests that use the cooling minimum air volume rate or heating full-load air volume rate, respectively.

As noted, sections 3.1.4.1.1.a, 3.1.4.2.a, and 3.1.4.3.a of appendix M1 specify using the air volume rates determined in those respective sections for all tests. By contrast, sections 3.2.2.2, 3.2.3.b, and 3.2.4.b specify using air volume rates that represent a "normal installation" when testing units having a single-speed compressor where the indoor section uses a single variable-speed variable-air-volume rate indoor blower or multiple indoor blowers (3.2.2.2), when testing units having a two-capacity compressor (3.2.3.b), and when testing units having a variable-speed compressor (3.2.4.b). In some cases, reference to "air volume rates that represent a normal installation" could conflict with the air volume rates determined in sections 3.1.4.1.1.a, 3.1.4.2.a, and 3.1.4.3.a.

For example, many modern blower-coil systems have multiple-speed or variable-speed indoor fans and control systems (*i.e.* the type of units covered under section 3.2.2.2) that may have the capability to vary fan speed in response to operating conditions in order to optimize performance. Under "normal installation" for such units, air volume rate changes in response to operating conditions such as outdoor air temperature. For these types of systems, the instructions in sections 3.1.4.1.1.a, 3.1.4.2.a, and 3.1.4.3.a to use a fixed (constant) air volume rate for all tests conflict with the instructions in sections 3.2.2.2, 3.2.3.b, and 3.2.4.b to use air volume rates that represent a normal installation.

For units with multiple-speed or variable-speed indoor fans and control systems that have the capability to vary fan speed in response to operating conditions, requiring air volume rate to remain constant as outdoor air temperature changes during testing may not provide test results that are representative of field operation.

To address this issue, DOE proposes to explicitly state in Step 7 of sections 3.1.4.1.1.a, 3.1.4.2.a, and 3.1.4.3.a that, for blower coil systems in which the indoor blower capacity modulation correlates with outdoor dry bulb temperature or sensible to total cooling capacity ratio, use an air volume rate that represents a normal operation. To ensure consistency of testing, it may be necessary for manufacturers to certify whether the system varies blower speeds with outdoor air conditions. However, this change is not being proposed in this notice and may be addressed in a separate rulemaking.

DOE requests comments on its proposal to add language clarifying how to implement variation of blower speed for different ambient temperature test conditions.

2. Wet Bulb Temperature for H4 5°F Heating Tests

Appendix M1 specifies required and optional heating mode test conditions for heat pumps, designated as "H" conditions. See Tables 11 through 15 of appendix M1. appendix M1 provides for conducting optional "H4" heating tests at a 5°F outdoor ambient dry-bulb temperature and, at a maximum, a 3°F outdoor wet-bulb temperature.[18] DOE initially proposed a target wet-bulb temperature for the H4 test of 3.5°F in an

[18] The tests at this condition are optional for heat pumps, except for Triple-Capacity Northern heat pumps.

SNOPR published in August 2016 ("August 2016 SNOPR"). 81 FR 58164, 58193. ACEEE, NRDC, and ASAP agreed with DOE's proposal of a target wet bulb temperature of 3.5 °F for the optional 5 °F test. (ACEEE, NRDC, and ASAP, EERE–2016–BT–TP–0029, No. 33 at p. 8) Carrier/UTC, Lennox, JCI, Ingersoll Rand, Goodman, Nortek, NEEA, Rheem, the CA IOUs, AHRI, and Mitsubishi all recommended that the target wet bulb temperature for the 5°F test should be 3°F or less, rather than the proposed 3.5°F target. The commenters indicated that holding tight tolerances on the wet bulb temperature at such low temperatures is very challenging, but the frost loading for this temperature is so low that the variation in the wet bulb temperature level would not affect the test significantly. Unico made a similar recommendation but suggested a maximum of 4°F wet bulb temperature. (Carrier/UTC, No. 36 at p. 12; Lennox, EERE–2016–BT–TP–0029, No. 25 at p. 15; JCI, EERE–2016–BT–TP–0029, No. 24 at p. 17; Ingersoll Rand, EERE–2016–BT–TP–0029, No. 38 at p. 7, Goodman No. 39 at p. 11; Nortek, EERE–2016–BT–TP–0029, No. 22 at p. 16; Unico, EERE–2016–BT–TP–0029, No. 30 at p. 7; NEEA, EERE–2016–BT–TP–0029, No. 35 at p. 3; Rheem, EERE–2016–BT–TP–0029, No. 37 at p. 6; CA IOU, EERE–2016–BT–TP–0029, No.32 at p.4; AHRI, EERE–2016–BT–TP–0029, No. 27 at p.19; Mitsubishi, No. 29 at p.4).

In the January 2017 TP Final Rule, DOE agreed that the amount of moisture in 5°F air would be sufficiently low that imposing a maximum wet bulb temperature of 3°F would be adequate to ensure test repeatability; hence DOE adopted the suggestion to require a 3°F maximum wet bulb temperature in the January 2017 TP Final Rule (82 FR 1426). Since the publication of the 2017 Final Rule, DOE and other stakeholders have gained additional experience testing to the new appendix M1, including testing at the 5°F H4 heating condition. DOE has received informal comments and has independently observed that holding the wet-bulb tolerance of maximum 3°F is difficult for some test labs, especially for extended periods of time, and that even if this low humidity level can be attained, the additional 0.5 to 1.0 °F wet bulb reduction adds significant time to testing (as compared to maximum wet bulb requirements of 3.5°F and 4°F, respectively).

The 3°F wet bulb condition represents an extremely dry air condition, which is difficult to attain and maintain due to issues with infiltration and ground moisture passing through the floor in some laboratory setups. Accordingly, DOE is proposing to amend the wet bulb test condition for all H4 tests to be 4°F maximum instead of the current condition of 3°F maximum. Because, as previously identified in comments, there is very little moisture content in the air at 5°F dry-bulb temperature, DOE does not expect that the change in wet bulb temperature condition will have a significant impact on test results.

DOE seeks comment on its proposal to amend the wet bulb temperature condition for the H4 heating tests from the existing 3°F maximum temperature to a maximum temperature of 4°F.

3. Hierarchy of Manufacturer Installation Instructions

Instructions for installation of CAC/HP products can take multiple forms, including documents shipped with the product, labels affixed to the outdoor unit and/or indoor unit, and online documents.

Section 2(A) of appendix M1 provides requirements regarding the installation instructions to be used and their order of precedence (*i.e.,* installation instruction hierarchy) for variable refrigerant flow ("VRF") multi-split systems. Section 2(A) specifies that installation instructions that appear in the labels applied to the unit take precedence over installation instructions that are shipped with the unit. Further, Section

2(A) specifies that the term "manufacturer's installation instructions" does not include online manuals. Appendix M1 does not specify installation instruction hierarchy for any other types of CAC/HP products.

Throughout appendix M1, references to manufacturer's installation instructions are made regarding refrigerant charging requirements (section 2.2.5), installation of an air supply plenum adapter accessory for testing small-duct, high-velocity systems (section 2.4.1.c), and control circuit connections between the furnace and the outdoor unit for coil-only systems (section 3.13.1.a).

DOE notes that it initially proposed in a supplemental NOPR published November 9, 2015 ("November 2015 SNOPR") that the hierarchy of installation instructions be located in proposed section 2.2.5.1 of appendix M1, which pertains to refrigerant charging requirements. See 80 FR 69278, 69350.[19] However, as finalized in the June 2016 Final Rule, the installation instruction hierarchy provision was located within section 2(A) of appendix M1, and therefore applies only to testing of VRF multi-split systems. 81 FR 36992, 37060. The June 2016 Final Rule did not provide a discussion of this change.

The requirements regarding installation instruction would be equally applicable to classes of CAC/HP other than VRF multi-split systems. As noted, manufacturer's installation instructions are referenced in a number of provisions in appendix M1. Therefore, DOE is proposing to add in section 2(B) of appendix M1, "Testing Overview and Conditions for Systems Other than VRF," the same requirements associated with

[19] DOE also notes that as initially proposed, installation instructions that are shipped with the unit were to take precedence over installation instructions that appear in the labels applied to the unit, but this hierarchy was reversed in the final rule. 81 FR 36992, 37060.

installation instructions that are in section 2(A), i.e. what instructions can be used and what instructions take precedence. This proposal would align the approach for all classes of CAC/HP with the current approach for VRF CAC.

DOE requests comment on the proposed alignment of the VRF and non-VRF test procedures when it comes to instruction precedence.

4. Adjusting Airflow Measurement Apparatus to Achieve Desired SCFM at Part-Load Conditions

DOE is aware that the specifications for cooling full-load air volume rates for both ducted and non-ducted units may require additional detail to provide improved repeatability. Sections 3.1.4.1.1, 3.1.4.2, and 3.1.4.4.3 of appendix M1 each specify seven steps for achieving the correct air volume rate to be used for testing (cooling full-load air volume rate, cooling minimum air volume rate, and heating full-load air volume rate, respectively). In each section, Step 7 mentions "fan speed" and "control settings" without indicating whether they are the speed and settings of the unit under test, of the airflow measurement apparatus, or both. DOE notes that cooling full-load air volume rate, cooling minimum air volume rate, and heating full-load air volume rate may each be used for multiple test conditions. However, when using this same air-volume rate at different test conditions, it may be necessary to adjust one of the fans to achieve the same air-volume rate, due to differences in air density and/or loading of condensate on the indoor coil.[20] In sections 3.1.4.1.1, 3.1.4.2, and 3.1.4.4.3 of appendix M1, Step 7 identifies the air volume rate (cooling full-load, cooling minimum, and heating full-load,

[20] When operating in cooling mode, water vapor in the return air may condense and collect and flow down the coil into the indoor unit's drain pan. This removal of water vapor is called dehumidification—it occurs only in cooling mode and its magnitude depends on the test conditions.

respectively) to be used for all test conditions that use the same air volume rate, but it does not indicate what adjustments are allowed or required to obtain it.

These sections may be misinterpreted to indicate that both the fan speed of the unit under test and the airflow measurement apparatus fan speed should not be adjusted during testing. As previously described, if both the test unit fan speed and the measurement apparatus fan speed are fixed, differences in air density and/or loading of condensate could cause differences in measured air volume rate at different test conditions, with no recourse for correction. This interpretation could then cause tests to be conducted at different air volume rates across test conditions, whereas the test procedure at sections 3.1.4.1.1, 3.1.4.2, and 3.1.4.4.3 of appendix M1 requires the tests to be conducted at the same air volume rate across different conditions. To minimize the potential for misinterpretation, DOE is proposing to explicitly require that the airflow measurement apparatus fan be adjusted if needed to maintain constant air volume rate for all tests using the same air volume rate. Similarly, the section would explicitly state that the speed and settings of the fan of the unit under test are not to be adjusted.

DOE requests comment on its proposal to add more specific direction to step 7 of sections 3.1.4.1.1, 3.1.4.2, and 3.1.4.4.3.

5. Revision of Equations Representing Full-Speed Variable-Speed Heat Pump Operation at and above 45 ºF Ambient Temperature

A compressor's speed at full speed may change as the outdoor temperature changes. While the compressor speed at full speed may differ at different outdoor temperatures, accuracy of predictions using the test results from two temperature conditions to calculate the performance for a third temperature condition is maximized when the same compressor speed is used for the tests at the two different ambient temperature conditions (see, e.g., 81 FR 58164, 58178 (August 24, 2016)).

For calculation of full-compressor performance in the temperature ranges less than 17 ºF and greater than or equal to 45 ºF, the test procedure determines performance based on the $H3_2$ and $H1_2$ tests, which are conducted at 17 ºF and 47 ºF, respectively (see appendix M1, sections 4.2.4.c, which refers to equations 4.2.2-3 and 4.2.2-4 in Section 4.2.2). As indicated in appendix M1 in the Table 14 footnotes, the $H1_2$ test is run with the compressor speed that represents normal operation at 17 ºF conditions. However, for many variable-speed heat pumps, this is a higher compressor speed than would be normal for operation at 47 ºF conditions.

The $H1_N$ test represents normal 47 ºF operation, as indicated in the Table 14 footnotes. For heat pumps with different normal speeds for 17 ºF and 47 ºF conditions, the full-compressor performance equation is not appropriately representative for temperatures greater than or equal to 45 ºF. For example, at 47 ºF, the equation would indicate that the capacity is equal to the $H1_2$ capacity, even though the $H1_N$ test is specifically intended to represent capacity at 47 ºF. To rectify this issue, DOE proposes to amend the portion of the equations representing performance in conditions warmer than 45 ºF. Specifically, the capacity equation for this temperature range would be multiplied by the ratio of the capacities of the $H1_N$ and $H1_2$ tests. Similarly, the power input equation for this range would be multiplied by the ratio of the power inputs measured in the $H1_N$ and $H1_2$ tests. This would change the calculated capacity and power input for the range of temperature above 45 ºF to be consistent with the compressor speed of the $H1_N$ test (which is intended to represent performance in this range), rather than with the compressor speed of the $H3_2$ test, which is conducted in a 17 ºF ambient temperature.

While DOE believes that the proposed amendments would provide more representative results, DOE does not expect that such changes would significantly affect heat pump HSPF2 measurements. This is because the full-capacity performance would affect HSPF2 only when the calculated building load exceeds the calculated intermediate capacity of a variable-speed heat pump, which DOE believes to be a rare occurrence in the ambient temperature range above 45 ºF. In the cases that would affect HSPF2, the change would increase the measured efficiency, since $H1_N$ COP is expected to be higher than $H1_2$ COP due to its lower compressor speed.

DOE requests comment on the proposed change to the full-capacity performance equations for variable-speed heat pumps in the ambient temperature range above 45 ºF, adjusting the equations for capacity and power by the ratio of capacity and power, respectively, associated with $H1_N$ and $H1_2$ operation.

6. Calculations for Triple-capacity Northern Heat Pumps

Section 4.2.6 of appendix M1 includes additional steps for calculating HSPF2 of a heat pump having a triple-capacity compressor. Heat pumps with triple-capacity compressors respond to building heating load by operating at low (k=1), high (k=2), or booster (k=3) capacity or by cycling on and off at one or more of those stages. Section 4.2.6.5 covers the scenario where the heat pump alternates between high (k=2) and booster (k=3) compressor capacity to satisfy the building load. In this scenario, the total electrical power consumption is determined by calculating the fraction of time the system spends operating in the high and booster stage, respectively, and then weighting the steady-state power consumption at each operating state accordingly. Section 4.2.6.5 gives equations for calculating the fraction of load addressed by the high compressor stage, denoted as "$X^{k=2}(T_j)$", as well as the fraction of load addressed by the booster compressor stage "$X^{k=3}(T_j)$". These proportions should, by definition, be complementary because the system is either operating in high compressor stage or boost compressor stage. However, the equation for the booster capacity load factor "$X^{k=3}(T_j)$" is erroneously set equal to the high-capacity load factor "$X^{k=2}(T_j)$" as opposed to the complementary value "1 $X^{k=2}(T_j)$." Therefore, DOE is proposing to correct the booster capacity load factor equation to be defined as $X^{k=3}(T_j) = 1 - X^{k=2}(T_j)$.

DOE seeks comment on its proposal to revise the calculation for booster capacity load factor equation for triple-capacity northern heat pumps.

7. Heating Nominal Air Volume Rate for Variable-Speed Heat Pumps

Appendix M1 includes procedures for calculating the heating capacity and power input for variable-speed heat pumps at various test conditions. The $H1_N$ test is used to calculate the nominal heating capacity of the system at 47°F ambient temperature, whereas the $H1_2$ test is used to calculate maximum heating capacity at 47°F and the $H1_1$ test is used to calculate minimum heating capacity at 47°F. Section 3.1.4.7 of appendix M1 requires that manufacturers must specify a heating nominal air volume rate for each variable-speed heat pump system and must provide instructions for setting the fan speed or controls. The heating full-load air volume rate is defined in section 3.1.4.4 of appendix M1, which ties the heating full-load air volume rate to the cooling full-load air volume rate and denotes static pressure requirements. However, in Table 14 to appendix M1 (which specifies heating mode test conditions for units having a variable-speed compressor), the $H1_N$ test (used for calculating nominal heating capacity at 47°F) is erroneously specified as using the “Heating Full-load” air volume rate instead of the heating nominal air volume rate. Because the $H1_N$ test is intended to represent nominal heating capacity, DOE is proposing to amend Table 14 to specify the “heating nominal air volume rate” as defined in section 3.1.4.7 of appendix M1 as opposed to the “heating full-load air volume rate”. As discussed in section I.B.2 of this NOPR, DOE is also proposing to amend the test provisions for variable-speed compressor systems with coil-only indoor units. The proposal mentioned in this section would only apply to variable-speed systems equipped with blower-coil indoor units, while variable-speed coil-only systems would be required to test using the heating full-load air volume rate at the $H1_N$ test condition.

DOE requests comment on its proposal to specify heating nominal air volume rate as the air volume rate to be used for the $H1_N$ heating test for variable-speed heat pumps.

8. Clarifications for HSPF2 Calculation

Section 4.2 of appendix M1 contains methodologies for calculating HSPF2 for all heat pumps. DOE has identified an instance where additional instruction may be warranted to make clear the calculation procedure across different types of heat pump systems. DOE proposes to clarify the appropriate slope adjustment factor to be used in the calculation for building heating load (Equation 4.2-2).

As written, Equation 4.2-2 refers to the heating load line slope adjustment factor “C”, which varies by climate region according to Table 20. However, Table 20 includes both the “C” factor as well as a factor denoted “C_{VS}” – the variable-speed slope factor, which includes different coefficients that impact calculation of HSPF2. C_{VS} is not explicitly referenced in the definitions surrounding Equation 4.2-2, therefor DOE is proposing to amend the language of that paragraph to indicate that the slope adjustment factor “C” should be used when calculating building heating load except for variable-speed compressor systems, where the variable-speed slope adjustment factor “C_{VS}” should be used instead.

DOE seeks comment on its proposal to clarify the calculation process for heating load line slope factor as it pertains to variable-speed heat pumps.

9. Distinguishing Central Air Conditioners and Heat Pumps from Commercial Equipment

EPCA defines “industrial equipment” as equipment of a type which, among other requirements, is not a covered product under section 6291(a)(2), i.e., not a covered consumer product. (42 U.S.C.6311(2)(A)) Small, large, and very large commercial package air conditioning and heating equipment are included as types of covered industrial equipment. (42 U.S.C.6311(1)(B,C,D))

EPCA defines “central air conditioner” as a product, other than a packaged terminal air conditioner, which is powered by single phase electric current, is air-cooled, is rated below 65,000 Btu per hour, is not contained within the same cabinet as a furnace the rated capacity of which is above 225,000 Btu per hour, and is a heat pump or a cooling only unit. DOE understands that there are basic models that exists on the market that meet the central air conditioner definition but are exclusively distributed in commerce for commercial and industrial applications. In DOE’s view, there are certain types of equipment that meet the definition of CAC but that EPCA was not intended to regulate as consumer products. To clarify that any such model is not a central air conditioner, DOE proposes to revise the central air conditioner definition so that it explicitly excludes these equipment categories, similar to the way the definition excludes packaged terminal air conditioners and packaged terminal heat pumps. The exclusion for single-package vertical air-conditioners and heat pumps would refer specifically to those models that could be confused with central air conditioners, i.e., those that are single-phase with capacity less than 65,000 Btu/h, for which the test procedure notice of proposed rulemaking for single-package vertical air conditioners and heat pumps has proposed new definitions. 87 FR 2490, 2518 (January 14, 2022).

DOE emphasizes that the exclusion from the central air conditioner definition for a given model depends on whether it meets the definition for one of the excluded categories. For example, a model must meet the packaged terminal air conditioner definition to be considered to be a packaged terminal air conditioner. Suppose a model meets the characteristics listed in the central air conditioner definition, but otherwise has similarities to packaged terminal air conditioners. If such a model is not “intended for mounting through the wall,” it would be missing a key characteristic of the packaged terminal air conditioner definition (see 10 CFR 431.92), and, unless it met the definition for one of the other categories proposed to be excluded, it is considered a central air conditioner irrespective of whether it gets installed in a consumer or commercial building.

10. Additional Test Procedure Revisions

On May 8, 2019, AHRI submitted a comment responding to the notice of proposal to revise and adopt procedures, interpretations, and policies for consideration of new or revised energy conservation standards (2020 Process Rule NOPR, 84 FR 3910, Feb. 13, 2019). The comment included as Exhibit 2 a “List of Errors Found in appendix M and appendix M1” (“AHRI Exhibit 2”, EERE-2017-BT-STD-0062-0117 at pp. 23-24). Many of the errors pointed out by AHRI regard typographical errors in appendix M and appendix M1. DOE published a notice of corrections to appendices M and M1 on December 2, 2021 ("December 2021 Corrections Notice"). 86 FR 68389. The December 2021 Corrections Notice addressed some of the "Errors" identified in AHRI Exhibit 2, but not all of them. DOE is proposing to address additional "Errors" identified in AHRI Exhibit 2 in this NOPR to improve accuracy and representativeness of the test procedures.

a. Revisions Specific to Appendix M

AHRI's comment identified three areas of appendix M where they requested changes. These are detailed in Table III-2. Additionally, DOE has identified one transcription error in the December 2021 Corrections Notice related to changes made in section 3.6.4 of appendix M. DOE is making corresponding revisions in this NOPR to correct that transcription error.

Table III-2: AHRI-Identified Errors to Appendix M

Section	Original Appendix M Language	AHRI Comment Summary	Proposed Change
1.2	"Nominal cooling capacity is approximate to the air conditioner cooling capacity tested at A or A_2 condition. Nominal heating capacity is approximate to the heat pump heating capacity tested in H12 test (or the optional H1N test)."	The $H1_N$ test is required in section 3.6.4, and section 3.6.4 designates the $H1_N$ test – not the $H1_2$ test.	Remove the "Optional $H1_N$ test" and replace the "$H1_2$" with "$H1_N$"
4.1.4.2	$A = EER^{k=1}(T_2) - B * T_2 - C * T_2^2$	The $EER^{k=1}(T_j)$ should be $EER^{k=2}(T_j)$ because the coefficient "A" only utilizes the maximum speed temperature, T_2.	Revise the formula to implement this change to $EER^{k=2}(T_j)$.
4.2.c	"For a variable-speed heat pump, $\dot{Q}_h^k(47) = \dot{Q}_h^{k=N}(47)$, the space heating capacity determined from the $H1_N$ test."	2017 and later versions of appendix M use $H^{k=2}_{calc}$ for all conditions, as	Accurately implement the change intended by the

		explained in 3.6.4. This should not be an exception for the rest of the calculations	December 2021 Corrections Notice.

The following sections discuss proposed changes to the language of appendix M that DOE believes will improve clarity regarding how tests and calculations are to be conducted to determine capacity levels and efficiency metrics.

i. Definition of Nominal Cooling Capacity

AHRI commented that the definition of Nominal Cooling Capacity in Section 1.2 of appendix M incorrectly references the $H1_N$ test as “optional.” AHRI claimed that, on the contrary, the $H1_N$ test is required for heat pumps. DOE agrees with the AHRI comment, since Section 3.6.4, “Tests for a Heat Pump Having a Variable-Speed Compressor,” requires the $H1_N$ test. Therefore, DOE is proposing to revise the definition of “Nominal Capacity” to remove the references to the $H1_2$ test in its entirety. Referring to the $H1_N$ test will avoid confusion.

ii. Revising Energy Efficiency Ratio Equation at Intermediate Compressor Speed

In section 4.1.4.2 of appendix M, there are a series of equations used to calculate $EER^{k=i}(T_j)$, the steady-state energy efficiency ratio of the test unit when operating at an intermediate compressor speed (k=i) for outdoor temperature T_j. This value is calculated using a quadratic equation: $EER^{k=i}(T_j) = A + B*T_j + C*T_j^2$. These coefficients (A, B and C) are calculated by their own respective formulae.

AHRI commented that the formula for the “A” coefficient has an error. Specifically, $EER^{k=1}(T_2)$ in the equation should be $EER^{k=2}(T_2)$ because the coefficient

"A" only utilizes maximum-speed temperature T_2. As described further in this section, DOE is proposing to revise this calculation such that it uses the intended "k=2". The use of "k=2" is supported both by its appearance in ASHRAE 116-2010, "Methods for Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps" (see page 25) and also in the DOE test procedure final rule that first established test methods for variable-speed systems. 49 FR 8304, 8316 (March 14, 1987).

iii. Clarification of Compressor Speed Limits in Heating Tests for Heat Pumps Having a Variable-Speed Compressor

In the December 2021 Corrections Notice, DOE discussed corrections to the compressor speed limitations for the $H1_N$ heating mode test for both appendix M and appendix M1. 86 FR 68389, 68390. However, when setting out the correcting language in the amendatory instruction for appendix M, the instructions erroneously directed to revise the fifth sentence of paragraph a to section 3.6.4, when the instructions were intended to revise the seventh sentence of the same paragraph. As currently printed, the text in paragraph a of section 3.6.4 to appendix M includes two sentences starting with "for a cooling/heating heat pump…" that give conflicting instructions. Accordingly, DOE is proposing to revise this paragraph to reflect the intent of the December 2021 Corrections Notice and, by extension, the January 2017 Final Rule.

b. Revisions Specific to Appendix M1

AHRI's comment identified one area of appendix M1 where they requested changes. This requested change is detailed in Table III-2.

Table III-3: AHRI-Identified Errors to Appendix M1

Section	Original Appendix M1 Language	AHRI Comment Summary	Proposed Change

4.2	$\dot{Q}_h(47°F)$: the heating capacity at 47 °F determined from the H2 $H1_2$ or $H1_N$ test, Btu/h.	For variable speed heat pumps, the language should be clarified to $H^{k=2}{}_{calc.}$	Revise the language to be clearer about what capacity to use for different types of heating-only heat pumps.

The following sections discuss proposed changes to the language of appendix M1 that DOE believes will improve clarity regarding how tests and calculations are to be conducted to determine capacity levels and efficiency metrics.

i. Detailed Descriptions of Capacity for Different Subcategories

AHRI commented that in Section 4.2 of appendix M1, which describes the calculation for HSPF2 for different subcategories of heat pumps, there is a lack of clarity in the term for heating capacity measured at 47 °F, "$\dot{Q}_h(47°F)$," in Equation 2-2, the building load, "$BL(T_j)$," equation. Currently, the description of $\dot{Q}_h(47°F)$ says that it is "determined from the H, $H1_2$ or $H1_N$ test." Additionally, the first "H" is missing an additional character to specify the appropriate test point. DOE agrees with AHRI's assessment of this description, and DOE is proposing to revise this description to include specific instructions for which test point is appropriate for different heat pump subcategories. DOE is proposing to specify that the H1 test is for a heat pump with a single-speed compressor, the $H1_2$ test is for a heat pump with a two-speed compressor, and the $H1_N$ test is for a heat pump with a variable-speed compressor.

However, AHRI commented regarding a "$H^{k=2}{}_{calc}$" term. DOE notes that this term does not exist in this section of appendix M1. While DOE is revising this section to add clarity in light of AHRI's general comment, DOE will not be proposing to make the exact edit AHRI proposes.

c. Revisions to Both Appendix M and Appendix M1

AHRI's comment claimed that there are two sections in both appendix M and appendix M1 that contain similar errors. These errors are detailed below in Table III-4.

Table III-4: AHRI-Identified Errors in Both Appendix M and Appendix M1

Section	Original Appendix M and Appendix M1 Language	AHRI Comment Summary	Proposed Change
4.2.3.3	$PLF_j = 1 - C_D^{h(k=2)} * [1 - X^{k=1}(T_j)$	The trailing square bracket "]" is missing and "$X^{k=1}(T_j)$" should be "$X^{k=2}(T_j)$"	Add the square bracket and revise the equation in appendix M.[1]
4.2.3.4	$\frac{RH(T_j)}{N} = (BL(T_j) * \frac{[Q_h^{k=2}(T_j) * \delta'(T_j)]}{3.413 \frac{Btu}{Wh}} * \frac{n_j}{N}$	The multiplication operator between $BL(T_j)$ and the square bracket should be subtraction	Revise the equation to have the subtraction

[1]The equation is correct in section 4.2.3.3 of appendix M1.

The following sections discuss proposed changes to the language of both appendix M and appendix M1 that DOE believes will improve clarity regarding how tests and calculations are to be conducted to determine capacity levels and efficiency metrics.

i. Revising Part Load Factor Equation for Heat Pumps in Section 4.2.3.3

AHRI's comment claims that the part load factor (PLF) equation in section 4.2.3.3 of both appendix M and appendix M1 contain two errors. The first error is that the equation is missing a closing square bracket, and the second is that the heating mode low-capacity load factor, "$X^{k=1}(T_j)$," is incorrectly referenced instead of the high-capacity load factor, "$X^{k=2}(T_j)$." DOE notes that this equation is actually correct in appendix M1. The high-capacity load factor is appropriate in this equation because section 4.2.3.3 applies to heat pumps that only operate at high (k=2) compressor capacity. Therefore, the high-capacity load factor should be used in this case for the part load factor. DOE is proposing to revise this formula in appendix M to include the closing square bracket and to use the high-capacity load factor.

ii. Revising the Ratio of Electrical Energy Used for Resistive Space Heating Equation in Section 4.2.3.4

AHRI has identified an error in the equation for electrical energy consumed by the heat pump for electric resistance auxiliary heating for bin temperature, T_j divided by the total number of hours in the heating season, "$RH(T_j)/N$," used in section 4.2.3.4 of both appendix M and appendix M1. AHRI indicated that the equation used in section 4.2.3.4 includes a multiplication operator where it should have subtraction. The subtraction operator is consistent with all other instances of $RH(T_j)/N$ in both appendix M and appendix M1. DOE agrees that the equation for $RH(T_j)/N$ in section 4.2.3.4 of both appendix M and appendix M1 is incorrect, and therefore DOE is proposing to revise this equation to include the subtraction operator rather than a multiplication operator.

DOE requests comments on the proposals to implement the correcting revisions described in this section.

D. Other Representation Proposed Revisions

Manufacturers, including importers, must use product-specific certification templates to certify compliance to DOE. For CAC/HPs, the certification template reflects the general certification requirements specified at 10 CFR 429.12 and the product-specific requirements specified at 10 CFR 429.16. As discussed in the previous paragraphs, DOE is not making any proposals related to certification requirements in this rulemaking and any such changes may be addressed in a future rulemaking.

1. Required Represented Values for Models Certified Compliant with Regional Standards

DOE's standards for CAC at 10 CFR 430.32(c) include both amended national standards with which compliance is required for models manufactured on or after January 1, 2023, and amended regional standards with which compliance is required for units installed on or after January 1, 2023. See 10 CFR 430.32(c)(5)-(6). In addition, as discussed in section III.B.3, DOE's regulations at 10 CFR 429.16 describe certification requirements for central air conditioners and central air conditioning heat pumps, and paragraph (a)(1) of this section requires single-split CACs with single-stage or two-stage compressors, at a minimum, to rate each outdoor model as part of a coil-only combination representative of the least efficient combination distributed in commerce with that particular outdoor unit.

On December 16, 2021, DOE issued final guidance regarding whether a model of outdoor unit for a single-split-system AC with single-stage or two-stage compressor whose coil-only rating under M1 does not meet regional standards, but where certain blower-coil combinations that include the outdoor model do meet regional standards, can be installed in the SE or SW region. DOE's guidance states that "In order to be installed in the SE or SW region, the outdoor unit must have at least one coil-only combination that is compliant with the regional standard applicable at the time of installation."

As background, DOE notes that it finalized provisions related to this issue in a June 2016 Test Procedure Final Rule (81 FR 36992, June 8, 2016) with minor revisions in a January 2017 Test Procedure Final Rule (82 FR 1426, January 5, 2017); a July 2016 Enforcement Final Rule (81 FR 45387, July 14, 2016); and a January 2017 Energy Conservation Standards Direct Final Rule (82 FR 1786, January 6, 2017). These provisions were based on consensus recommendations by two ASRAC Working Groups -

a Regional Standards Enforcement Working Group ("Enforcement WG") that concluded on October 24, 2014 (See final report: Docket No. EERE–2011–BT–CE–0077, No. 70), and a Central Air Conditioner and Heat Pump Energy Conservation Standards Working Group ("ECS WG") that concluded on January 19, 2016 (See term sheet: Docket No. EERE-2014-BT-STD-0048, No. 76).

The July 2016 Enforcement Final Rule adopted several provisions of relevance here, with a focus on enforcement of the existing energy conservation standards:

- **10 CFR 429.102(c)(4)** contains provisions regarding what a "product installed in violation" includes, specifying, among other things: "(i) A complete central air conditioning system that is not certified as a complete system that meets the applicable standard. Combinations that were previously validly certified may be installed after the manufacturer has discontinued the combination, provided the combination meets the currently applicable standard. … [and] (iii) An outdoor unit that is part of a certified combination rated less than the standard applicable in the region in which it is installed." 81 FR 45387, 45393-45394.
- **10 CFR 429.158(a)** specifies that if DOE determines a model of outdoor unit fails to meet the applicable regional standard(s) when tested in a combination certified by the same manufacturer, then the outdoor unit basic model will be deemed noncompliant with the regional standard(s). 81 FR 45387, 45397.
- **10 CFR 430.32(c)(3)-(4)** provides that any outdoor unit model that has a certified combination with a rating below 14 SEER cannot be installed in either the southern or southwest region. 81 FR 45387, 45391.

The June 2016 TP Final Rule adopted several certification provisions of relevance here, with a focus on the amended energy conservation standards recommended by the

ECS WG. In particular, the June 2016 TP Final Rule noted that the ECS WG recommended energy conservation standards for central air conditioners based on coil-only ratings. 81 FR 36992, 37002. (June 8, 2016). The recommended standard levels for split system air conditioners may very well have been higher if they had been based on blower-coil ratings. For example, the recommended standard levels for split system heat pumps, which are based on blower-coil ratings, are approximately one point higher than those for split system air conditioners.

In addition, the ECS WG recommended that DOE implement the requirement that every single-split air conditioner combination distributed in commerce must be rated, and that every single-stage and two-stage condensing (outdoor) unit distributed in commerce (other than a condensing unit for a 1-to-1 mini split) must have at least 1 coil-only rating that is representative of the least efficient coil distributed in commerce with a particular condensing unit. Every condensing unit distributed in commerce must have at least 1 tested combination, and for single-stage and two-stage condensing units (other than condensing units for a 1-to-1 mini split) this must be a coil-only combination. (Docket No. EERE-2014-BT-STD-0048, No. 76, Recommendation #7) In the June 2016 Final Rule, DOE adopted these recommendations along with regional limitations for represented values of individual combinations:

- **10 CFR 429.16(a)(1)** contains provisions for required represented values, stating that for single-split system AC with single-stage or two-stage compressor, every individual combination distributed in commerce must be rated as a coil-only combination. For each model of outdoor unit, this must include at least one coil-only value that is representative of the least efficient combination distributed in commerce with that particular model of outdoor unit. Additional blower-coil representations are allowed for any applicable individual combinations, if distributed in commerce. 81 FR 36992, 37002.

- **10 CFR 429.16(b)(2)(i)** specifies that for each basic model of single-split system AC with single-stage or two-stage compressor, the model of outdoor unit must be tested with a model of coil-only indoor unit. 81 FR 36992, 37002.
- **10 CFR 429.16(a)(4)(i)** [as modified in the January 2017 TP Final Rule] states that a basic model may only be certified as compliant with a regional standard if all individual combinations within that basic model meet the regional standard for which it is certified, and that a model of outdoor unit that is certified below a regional standard can only be rated and certified as compliant with a regional standard if the model of outdoor unit has a unique model number and has been certified as a different basic model for distribution in each region. 81 FR 36992, 37012 [as 10 CFR 429.16(a)(3)(i)]; 82 FR 1426.

DOE notes that the July 2016 Enforcement Final Rule stated that the adopted provisions in 10 CFR 430.32(c)(3)-(4) were meant to be complementary to the regional limitations adopted in the June 2016 TP Final Rule at 10 CFR 429.16(a)(3)(i) [now 10 CFR 429.16(a)(4)(i)]. 81 FR 45387, 45391. In the January 2017 CAC DFR, DOE adopted additional language in 10 CFR 430.32 relevant to the amended standards:

- **10 CFR 430.32(c)(6)(ii)** provides that any outdoor unit model that has a certified combination with a rating below the applicable standard level(s) for a region cannot be installed in that region. The least-efficient combination of each basic model must comply with this standard. 82 FR 1786, 1857.

Finally, DOE notes that the general enforcement provisions in Subpart C to part 429 also apply to CAC standards (both national and regional), including:

- **10 CFR 429.102(a)(1)**, specifying that the failure of a manufacturer to properly certify covered products in accordance with 10 CFR 429.12 and 429.14 through 429.62 is a prohibited act subject to enforcement action.

Taken together, the regional standards, certification, and enforcement provisions require that, in order to comply with a regional standard, the least efficient combination of each basic model must comply. 10 CFR 430.32(c)(6)(ii). Further, each basic model of single-split system AC with single-stage or two-stage compressor must include a represented value for a coil-only combination representative of the least efficient combination distributed in commerce with the model of outdoor unit, and each model of outdoor unit must be tested with a model of coil-only indoor unit. (10 CFR 429.16(a)(1) and 429.16(b)(2)(i)). While manufacturers can create a regional-specific basic model under 10 CFR 429.16(a)(4)(i), such a basic model must still be certified properly according to the other provisions in that section. As such, in order to comply with a regional standard, a regional-specific basic model of single-split system AC with single-stage or two-stage compressor must include at least one coil-only combination that complies with the regional standard. Failure to certify a regional-specific basic model according to the provisions in 10 CFR 429.16(a)(1) and 429.16(b)(2)(i) is a prohibited act under 10 CFR 429.102(a)(1).

Similarly, while 10 CFR 429.102(c)(4)(i) states that combinations that were previously validly certified may be installed after the manufacturer has discontinued the combination, provided the combination meets the currently applicable standard. The provision at 10 CFR 429.102(c)(4)(i) was designed to allow sell-through of inventory that manufacturers had discontinued for reasons other than non-compliance with a regional standard. 81 FR 45387, 45393. It was not intended, nor in the light of all other provisions can it be read, as allowing installation of models of outdoor unit that do not comply with the applicable regional standard at the time of installation (i.e., have no combinations of coil-only units that comply with the amended regional standards, which, as stated previously, were developed based on coil-only ratings).

Based on this background, the CAC regional guidance states in part:

In general, a basic model may be certified as compliant with a regional standard (and, as of January 1, 2023, meets the applicable amended regional standard) only if all individual combinations within that basic model meet the regional standard for which it is certified. All individual model combinations within a basic model must include, for single-split-system AC with single-stage or two-stage compressor (including space-constrained and SDHV systems), a coil-only combination representative of the least-efficient combination in which the specific outdoor unit is distributed in commerce. *See* 10 CFR 429.16(a)(1); 429.16(a)(4)(i); 430.32(c)(6).

A manufacturer may sell an outdoor unit of identical design in the SE and SW regions, if the manufacturer separates the basic model (i.e. outdoor unit model) into different basic models with unique model numbers for distribution in each region, provided that the basic models for the SE and SW regions: (1) do not include any individual combinations that are not compliant with the regional standard applicable at the time of installation; and (2) include at least one coil-only combination that is representative of the least-efficient combination in which the specific outdoor unit is distributed in commerce. *Id*.

DOE notes that the install-through provisions in 10 CFR 429.102(c)(4)(i) allows existing stock of discontinued basic model combinations to be installed in the SE or SW regions as long as they were previously validly certified as compliant to the regional standards applicable at the time of installation. DOE further notes that the term "previously validly certified" means that all combinations within the basic model must show compliance with the regional standard applicable at the time of installation, including, for single-split-system AC with single-stage or two-stage compressor (including space-constrained and SDHV systems), a coil-only combination representative of the least-efficient combination in which the specific outdoor unit is distributed in commerce, in order for the install-through provisions to apply.

DOE proposes to add additional direction to the regulatory text in 10 CFR 429.16(a)(1) and (a)(4)(i), 10 CFR 429.102(c)(4)(i) and (iii), and 10 CFR 430.32(c)(6)(ii) to more explicitly cross-reference the existing regulatory text to clarify the interplay of the existing requirements and reinforce the guidance.

In addition, DOE notes that the table in 10 CFR 429.16(a)(1) states that the required coil-only value must be "representative of the least efficient combination *distributed in commerce with that particular model of outdoor unit*" (emphasis added). Sections 429.140 through 429.158 provide enforcement procedures specific to regional standards, 10 CFR 429.142 includes records retention of information regarding sales of outdoor units, indoor units, and single-package units, and 10 CFR 429.144 specifies requirements for records requests. When determining if a model of indoor unit is distributed in commerce with a particular model of outdoor unit, DOE may review catalogs, product literature, installation instructions, and advertisements, and may also request sales records.

Finally, 10 CFR 429.158 discusses products determined noncompliant with regional standards. Paragraphs (a) and (b) cross-reference 10 CFR 429.102(c), stating that the certifying manufacturer is liable for distribution of noncompliant units in commerce. DOE notes that 10 CFR 429.102(c) refers to distributors, contractors, and dealers, while 10 CFR 429.102(a)(10) states that it is prohibited "for any manufacturer or private labeler to knowingly sell a product to a distributor, contractor, or dealer with knowledge that the entity routinely violates any regional standard applicable to the product." Therefore, DOE proposes that 10 CFR 429.158(a)-(b) cross-reference 10 CFR 429.102(a)(10) rather than 10 CFR 429.102(c).

DOE requests comment on its proposals to the regulatory text in 10 CFR part 429, and in particular, whether they clarify the requirements and align with DOE's issued guidance or whether additional clarification is needed.

E. Test Procedure Costs and Impact

As discussed, DOE's existing test procedures for CAC/HPs appear at appendix M and appendix M1 (both titled "Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps"). In this NOPR, DOE proposes to amend the existing test procedure for CACs and HPs to provide additional detail and instruction to ensure the representativeness of the test procedure and to reduce potential burden. As discussed, DOE is proposing limited amendments to appendix M1, which is the required test procedure beginning January 1, 2023.

DOE has tentatively determined that the proposed amendments in this NOPR would improve the representativeness, accuracy, and reproducibility of the test results, and they would not be unduly burdensome for manufacturers to conduct or result in increased testing cost as compared to the current test procedure.

The proposed amendment to the wet bulb temperature maximum for the 5°F ambient temperature condition, discussed in section III.C.2, would amend the condition from 3°F to 4°F. This change is proposed based, in part, on feedback from manufacturers that the proposed change to 4°F would be easier to achieve than 3°F. As such, DOE does not anticipate that this provision would increase the burden of conducting testing under appendix M1.

With regards to the additional test procedure proposals introduced in sections III.B and III.C of this NOPR, DOE does not believe that these will cause manufacturers to incur any additional test procedure costs. The proposals to (a) define revised fan wattages for low-stage testing of two-stage coil-only units, and (b) revise the equations for full-capacity operation of variable-speed heat pumps at and above 45 ºF affect calculations rather than testing. The proposals for variable-speed coil-only air conditioners and heat pumps provide instructions for testing such models that are currently the subject of test procedure waivers. The proposals to (a) revise text regarding variation of fan speed with ambient temperature, (b) explicitly indicate that the airflow measurement apparatus fan should be adjusted to maintain constant airflow for certain models, and (c) clarify that the instructions on a label affixed to the unit take precedence over the instructions shipped with the unit provide additional instruction to improve consistency of testing but would not increase either the number of tests or the duration of tests. Finally, the proposed changes in 10 CFR part 429 neither modify the test procedure nor increase the number of units that would be required to be tested. Thus, DOE does not anticipate these additional procedures would cause any increased test procedure costs.

F. Compliance Date and Waivers

EPCA prescribes that, if DOE amends a test procedure, all representations of energy efficiency and energy use, including those made on marketing materials and product labels, must be made in accordance with that amended test procedure, beginning 180 days after publication of such a test procedure final rule in the *Federal Register*. (42 U.S.C. 6293(c)(2))

If DOE were to publish an amended test procedure EPCA provides an allowance for individual manufacturers to petition DOE for an extension of the 180-day period if the manufacturer may experience undue hardship in meeting the deadline. (42 U.S.C. 6293(c)(3)) To receive such an extension, petitions must be filed with DOE no later than 60 days before the end of the 180-day period and must detail how the manufacturer will experience undue hardship. (*Id.*)

Upon the compliance date of test procedure provisions of an amended test procedure, should DOE issue a such an amendment, any waivers that had been previously issued and are in effect that pertain to issues addressed by such provisions are terminated. 10 CFR 430.27(h)(3). Recipients of any such waivers would be required to test the products subject to the waiver according to the amended test procedure as of the compliance date of the amended test procedure. The amendments proposed in this document pertain to issues addressed by waivers granted to GD Midea Heating and Ventilating Equipment Co., (83 FR 56065, Case No. 2017-013), and TCL AC (84 FR 11941, Case No. 2018-009); and interim waivers granted to Aerosys (83 FR 24762, Case

No. 2017-008), LG Electronics (85 FR 40272, Case No. 2019-008), and Goodman (86 FR 40534, Case No. 2021-001). To the extent such waivers and interim waivers permit the petitioner to test according to an alternate test procedure to appendix M, such waivers and interim waivers will terminate on the date testing is required according to appendix M1 (i.e., January 1, 2023), independent of this rulemaking. To the extent that such waivers and interim waivers permit the petitioner to test according to an alternate test procedure to appendix M1 at such time as testing is required according to appendix M1, such waivers and interim waivers would terminate on January 1, 2023, if the amendments in this NOPR are adopted as proposed.

DOE notes that the waiver issued to Johnson Controls (83 FR 12735, Case No. CAC-051; 84 FR 52489, Case No. CAC-050) and interim waiver granted to National Comfort Products (83 FR 24754, Case No. 2017-008) will terminate on January 1, 2023, the date beginning which testing according to appendix M1 is required, independent of this NOPR.

IV. Procedural Issues and Regulatory Review

A. Review Under Executive Order 12866

The Office of Management and Budget ("OMB") has determined that this test procedure rulemaking does not constitute a "significant regulatory action" under section 3(f) of Executive Order ("E.O.") 12866, Regulatory Planning and Review, 58 FR 51735 (Oct. 4, 1993). Accordingly, this action was not subject to review under the Executive order by the Office of Information and Regulatory Affairs ("OIRA") in OMB.

B. Review Under the Regulatory Flexibility Act

The Regulatory Flexibility Act (5 U.S.C. 601 *et seq.*) requires preparation of an initial regulatory flexibility analysis ("IRFA") for any rule that by law must be proposed for public comment, unless the agency certifies that the rule, if promulgated, will not have a significant economic impact on a substantial number of small entities. As required by Executive Order 13272, "Proper Consideration of Small Entities in Agency Rulemaking," 67 FR 53461 (August 16, 2002), DOE published procedures and policies on February 19, 2003, to ensure that the potential impacts of its rules on small entities are properly considered during the DOE rulemaking process. 68 FR 7990. DOE has made its procedures and policies available on the Office of the General Counsel's website: *energy.gov/gc/office-general-counsel*.

DOE reviewed this proposed rule under the provisions of the Regulatory Flexibility Act and the procedures and policies published on February 19, 2003. DOE certifies that the proposed rule, if adopted, would not have significant economic impact on a substantial number of small entities. The factual basis of this certification is set forth in the following paragraphs.

Under 42 U.S.C. 6293, the statute sets forth the criteria and procedures DOE must follow when prescribing or amending test procedures for covered products. EPCA requires that any test procedures prescribed or amended under this section must be reasonably designed to produce test results which measure energy efficiency, energy use or estimated annual operating cost of a covered product during a representative average use cycle or period of use and not be unduly burdensome to conduct. (42 U.S.C. 6293(b)(3))

DOE is proposing a limited number of amendments to the test procedure for central air conditioners and heat pumps ("CAC/HPs") to address specific issues that have been raised in test procedure waivers regarding appendix M1 to subpart B of 10 CFR part 430.

In this NOPR, DOE proposes the following updates to the test procedure for CACs/HPs:

1. Update default fan power for coil-only CACs and HPs that can utilize different fan speeds and the 75% intermediate airflow.

2. Define "Communicating Variable-speed Coil-only Central Air Conditioner or Heat Pump" and prescribing an appropriate test procedure.

3. Add the control system capability to adjust air volume rate as a function of outdoor air temperature for blower coil systems with multiple-speed or variable-speed indoor fans.

4. Amend the wet bulb test condition for the 5°F dry, outdoor ambient test to have a 4°F maximum.

5. Add direction to prioritize the instructions presented in the label attached to the unit over the instructions included in the installation instructions shipped with the unit.

6. Add specific instruction to adjust the exhaust fan speed to achieve a constant cooling full-load air volume rate through the airflow measurement apparatus.

7. Revise the equations representing full-capacity performance of variable-speed heat pumps for the temperature range above 45 ºF to be more consistent with field operation.

8. Providing additional direction regarding the regional standard requirements in 10 CFR part 429.

For manufacturers of CACs/HPs, the Small Business Administration ("SBA") has set a size threshold, which defines those entities classified as "small businesses" for the purposes of the statute. DOE used the SBA's small business size standards to determine whether any small entities would be subject to the requirements of the rule. See 13 CFR part 121. The equipment covered by this rule is classified under North American Industry Classification System ("NAICS") code 333415,[21] "Air-Conditioning and Warm Air Heating Equipment and Commercial and Industrial Refrigeration Equipment Manufacturing." In 13 CFR 121.201, the SBA sets a threshold of 1,250 employees or fewer for an entity to be considered as a small business for this category. DOE identified manufacturers using DOE's Compliance Certification Database ("CCD"),[22] the AHRI database,[23] the California Energy Commission's Modernized Appliance Efficiency Database System ("MAEDbS"),[24] the ENERGY STAR Product Finder database,[25] and the prior CAC/HP rulemakings. DOE used the publicly available information and

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[21] The size standards are listed by NAICS code and industry description and are available at: *www.sba.gov/document/support--table-size-standards* (Last accessed on October 1, 2021).
[22] DOE's Compliance Certification Database is available at: *www.regulations.doe.gov/ccms* (last accessed October 11, 2021).
[23] The AHRI Database is available at: *www.ahridirectory.org/* (last accessed October 1, 2021).
[24] California Energy Commission's MAEDbS is available at *cacertappliances.energy.ca.gov/Pages/ApplianceSearch.aspx* (last accessed October 1, 2021).
[25] The ENERGY STAR Product Finder database is available at *energystar.gov/productfinder/* (last accessed September 22, 2021).

subscription-based market research tools (*e.g.,* reports from Dun & Bradstreet[26]) to identify 33 original equipment manufacturers ("OEMs") of the covered equipment. Of the 33 OEMs, DOE identified eight domestic manufacturers of CACs/HPs that meet the SBA definition of a "small business."

This NOPR proposes amendments to the test procedure for CAC/HP for which compliance is not required until January 1, 2023. As discussed in more detail in section III.E of this document, DOE has initially determined that the proposed amendments to the test procedure would not require retesting or re-rating, with the potential exception of variable-speed coil-only units. While DOE believes the variable-speed coil-only units will be isolated to a very small fraction of models distributed in commerce (i.e., less than 1 percent based on manufacturer representations in DOE's current Compliance Management Database), a manufacturer will have need to ensure their representations are made in accordance with these amendments if finalized. DOE notes that none of the variable-speed coil-only basic models certified currently with DOE are manufactured by small manufacturers. Additionally, the test procedure amendments would not result in any change in burden associated the DOE test procedure for CACs/HP. Therefore, DOE initially concludes that the test procedure amendments proposed in this NOPR would not have a "significant economic impact on a substantial number of small entities," and that the preparation of an IRFA is not warranted. DOE will transmit the certification and supporting statement of factual basis to the Chief Counsel for Advocacy of the Small Business Administration for review under 5 U.S.C. 605(b). DOE welcomes comment on the Regulatory Flexibility certification conclusion.

[26] *app.dnbhoovers.com*

C. Review Under the Paperwork Reduction Act of 1995

Manufacturers of CAC/HP must certify to DOE that their products comply with any applicable energy conservation standards. To certify compliance, manufacturers must first obtain test data for their products according to the DOE test procedures, including any amendments adopted for those test procedures. DOE has established regulations for the certification and recordkeeping requirements for all covered consumer products and commercial equipment, including CACs/HPs. (See generally 10 CFR part 429.) The collection-of-information requirement for the certification and recordkeeping is subject to review and approval by OMB under the Paperwork Reduction Act ("PRA"). This requirement has been approved by OMB under OMB control number 1910-1400. Public reporting burden for the certification is estimated to average 35 hours per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information.

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to a penalty for failure to comply with, a collection of information subject to the requirements of the PRA, unless that collection of information displays a currently valid OMB Control Number.

D. Review Under the National Environmental Policy Act of 1969

In this NOPR, DOE proposes test procedure amendments that it expects will be used to develop and implement future energy conservation standards for CAC/HP. DOE has determined that this proposed rule falls into a class of actions that are categorically excluded from review under the National Environmental Policy Act of 1969 (42 U.S.C. 4321 *et seq*.) and DOE's implementing regulations at 10 CFR part 1021. Specifically, DOE has determined that adopting test procedures for measuring energy efficiency of consumer products and industrial equipment is consistent with activities identified in 10 CFR part 1021, appendix A to subpart D, A5 and A6. Accordingly, neither an environmental assessment nor an environmental impact statement is required.

E. Review Under Executive Order 13132

Executive Order 13132, "Federalism," 64 FR 43255 (Aug. 4, 1999) imposes certain requirements on agencies formulating and implementing policies or regulations that preempt State law or that have federalism implications. The Executive order requires agencies to examine the constitutional and statutory authority supporting any action that would limit the policymaking discretion of the States and to carefully assess the necessity for such actions. The Executive order also requires agencies to have an accountable process to ensure meaningful and timely input by State and local officials in the development of regulatory policies that have federalism implications. On March 14, 2000, DOE published a statement of policy describing the intergovernmental consultation process it will follow in the development of such regulations. 65 FR 13735. DOE has examined this proposed rule and has determined that it would not have a substantial direct effect on the States, on the relationship between the national government and the States, or on the distribution of power and responsibilities among the various levels of government. EPCA governs and prescribes Federal preemption of State regulations as to energy conservation for the products that are the subject of this proposed rule. States can petition DOE for exemption from such preemption to the extent, and based on criteria, set forth in EPCA. (42 U.S.C. 6297(d)) No further action is required by Executive Order 13132.

F. Review Under Executive Order 12988

Regarding the review of existing regulations and the promulgation of new regulations, section 3(a) of Executive Order 12988, "Civil Justice Reform," 61 FR 4729 (Feb. 7, 1996), imposes on Federal agencies the general duty to adhere to the following requirements: (1) eliminate drafting errors and ambiguity, (2) write regulations to minimize litigation, (3) provide a clear legal standard for affected conduct rather than a general standard, and (4) promote simplification and burden reduction. Section 3(b) of Executive Order 12988 specifically requires that executive agencies make every reasonable effort to ensure that the regulation (1) clearly specifies the preemptive effect, if any, (2) clearly specifies any effect on existing Federal law or regulation, (3) provides a clear legal standard for affected conduct while promoting simplification and burden reduction, (4) specifies the retroactive effect, if any, (5) adequately defines key terms, and (6) addresses other important issues affecting clarity and general draftsmanship under any guidelines issued by the Attorney General. Section 3(c) of Executive Order 12988 requires Executive agencies to review regulations in light of applicable standards in sections 3(a) and 3(b) to determine whether they are met, or it is unreasonable to meet one or more of them. DOE has completed the required review and determined that, to the extent permitted by law, the proposed rule meets the relevant standards of Executive Order 12988.

G. Review Under the Unfunded Mandates Reform Act of 1995

Title II of the Unfunded Mandates Reform Act of 1995 ("UMRA") requires each Federal agency to assess the effects of Federal regulatory actions on State, local, and Tribal governments and the private sector. Pub. L. 104-4, sec. 201 (codified at 2 U.S.C. 1531). For a proposed regulatory action likely to result in a rule that may cause the expenditure by State, local, and Tribal governments, in the aggregate, or by the private sector of $100 million or more in any one year (adjusted annually for inflation), section 202 of UMRA requires a Federal agency to publish a written statement that estimates the resulting costs, benefits, and other effects on the national economy. (2 U.S.C. 1532(a), (b)) The UMRA also requires a Federal agency to develop an effective process to permit timely input by elected officers of State, local, and Tribal governments on a proposed "significant intergovernmental mandate," and requires an agency plan for giving notice and opportunity for timely input to potentially affected small governments before establishing any requirements that might significantly or uniquely affect small governments. On March 18, 1997, DOE published a statement of policy on its process for intergovernmental consultation under UMRA. 62 FR 12820; also available at *http://energy.gov/gc/office-general-counsel*. DOE examined this proposed rule according to UMRA and its statement of policy and determined that the rule contains neither an intergovernmental mandate, nor a mandate that may result in the expenditure of $100 million or more in any year, so these requirements do not apply.

H. Review Under the Treasury and General Government Appropriations Act, 1999

Section 654 of the Treasury and General Government Appropriations Act, 1999 (Pub. L. 105-277) requires Federal agencies to issue a Family Policymaking Assessment for any rule that may affect family well-being. This proposed rule would not have any impact on the autonomy or integrity of the family as an institution. Accordingly, DOE has concluded that it is not necessary to prepare a Family Policymaking Assessment.

I. Review Under Executive Order 12630

DOE has determined, under Executive Order 12630, "Governmental Actions and Interference with Constitutionally Protected Property Rights" 53 FR 8859 (March 18, 1988), that this proposed regulation would not result in any takings that might require compensation under the Fifth Amendment to the U.S. Constitution.

J. Review Under Treasury and General Government Appropriations Act, 2001

Section 515 of the Treasury and General Government Appropriations Act, 2001 (44 U.S.C. 3516 note) provides for agencies to review most disseminations of information to the public under guidelines established by each agency pursuant to general guidelines issued by OMB. OMB's guidelines were published at 67 FR 8452 (Feb. 22, 2002), and DOE's guidelines were published at 67 FR 62446 (Oct. 7, 2002). Pursuant to OMB Memorandum M-19-15, Improving Implementation of the Information Quality Act (April 24, 2019), DOE published updated guidelines which are available at *www.energy.gov/sites/prod/files/2019/12/f70/DOE%20Final%20Updated%20IQA%20Guidelines%20Dec%202019.pdf*. DOE has reviewed this proposed rule under the OMB and DOE guidelines and has concluded that it is consistent with applicable policies in those guidelines.

K. Review Under Executive Order 13211

Executive Order 13211, "Actions Concerning Regulations That Significantly Affect Energy Supply, Distribution, or Use," 66 FR 28355 (May 22, 2001), requires Federal agencies to prepare and submit to OMB, a Statement of Energy Effects for any proposed significant energy action. A "significant energy action" is defined as any action by an agency that promulgated or is expected to lead to promulgation of a final rule, and that (1) is a significant regulatory action under Executive Order 12866, or any successor order; and (2) is likely to have a significant adverse effect on the supply, distribution, or use of energy; or (3) is designated by the Administrator of OIRA as a significant energy action. For any proposed significant energy action, the agency must give a detailed statement of any adverse effects on energy supply, distribution, or use should the proposal be implemented, and of reasonable alternatives to the action and their expected benefits on energy supply, distribution, and use.

The proposed regulatory action to amend the test procedure for measuring the energy efficiency of CAC/HPs is not a significant regulatory action under Executive Order 12866. Moreover, it would not have a significant adverse effect on the supply, distribution, or use of energy, nor has it been designated as a significant energy action by the Administrator of OIRA. Therefore, it is not a significant energy action, and, accordingly, DOE has not prepared a Statement of Energy Effects.

L. Review Under Section 32 of the Federal Energy Administration Act of 1974

Under section 301 of the Department of Energy Organization Act (Pub. L. 95–91; 42 U.S.C. 7101), DOE must comply with section 32 of the Federal Energy Administration Act of 1974, as amended by the Federal Energy Administration Authorization Act of 1977. (15 U.S.C. 788; "FEAA") Section 32 essentially provides in relevant part that, where a proposed rule authorizes or requires use of commercial standards, the notice of proposed rulemaking must inform the public of the use and background of such standards. In addition, section 32(c) requires DOE to consult with the Attorney General and the Chairman of the Federal Trade Commission ("FTC") concerning the impact of the commercial or industry standards on competition.

The proposed modifications to the test procedure for CACs/HPs would maintain the incorporation of testing methods contained in certain sections of the following commercial standards: ANSI/AHRI 210/240–2008 with Addenda 1 and 2, ("AHRI 210/240–2008"): 2008 Standard for Performance Rating of Unitary Air-Conditioning &

Air-Source Heat Pump Equipment, ANSI approved October 27, 2011; ANSI/AHRI 1230–2010 with Addendum 2, ("AHRI 1230–2010"): 2010 Standard for Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment, ANSI approved August 2, 2010; ANSI/ASHRAE 23.1–2010, ("ASHRAE 23.1–2010"): Methods of Testing for Rating the Performance of Positive Displacement Refrigerant Compressors and Condensing Units that Operate at Subcritical Temperatures of the Refrigerant, ANSI approved January 28, 2010; ANSI/ASHRAE Standard 37–2009, ("ANSI/ASHRAE 37–2009"), Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment, ANSI approved June 25, 2009; ANSI/ASHRAE 41.1–2013, ("ANSI/ASHRAE 41.1–2013"): Standard Method for Temperature Measurement, ANSI approved January 30, 2013; ANSI/ASHRAE 41.6–2014, (''ASHRAE 41.6–2014''): Standard Method for Humidity Measurement, ANSI approved July 3, 2014; ANSI/ASHRAE 41.9–2011, ("ASHRAE 41.9–2011"): Standard Methods for Volatile-Refrigerant Mass Flow Measurements Using Calorimeters, ANSI approved February 3, 2011; ANSI/ASHRAE 116–2010, ("ASHRAE 116–2010"): Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps, ANSI approved February 24, 2010; ANSI/ASHRAE 41.2–1987 (Reaffirmed 1992), ("ASHRAE 41.2–1987 (RA 1992)"): "Standard Methods for Laboratory Airflow Measurement", ANSI approved April 20, 1992; and ANSI/AMCA 210–2007, ANSI/ASHRAE 51–2007, ("AMCA 210–2007") Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating, ANSI approved August 17, 2007.

DOE has evaluated these standards and is unable to conclude whether they fully comply with the requirements of section 32(b) of the FEAA (*i.e.*, whether it was developed in a manner that fully provides for public participation, comment, and review.) DOE will consult with both the Attorney General and the Chairman of the FTC concerning the impact of these test procedures on competition, prior to prescribing a final rule.

M. Description of Materials Incorporated by Reference.

The following standard was previously approved for incorporation by reference in appendix M1 where it appears and no change is proposed:

ANSI/ASHRAE Standard 37–2009, Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment, ANSI approved June 25, 2009;

V. Public Participation

A. Submission of Comments

DOE will accept comments, data, and information regarding this proposed rule no later than the date provided in the DATES section at the beginning of this proposed rule.[27] Interested parties may submit comments using any of the methods described in the **ADDRESSES** section at the beginning of this document.

[27] DOE has historically provided a 75-day comment period for test procedure NOPRs pursuant to the North American Free Trade Agreement, U.S.-Canada-Mexico ("NAFTA"), Dec. 17, 1992, 32 I.L.M. 289 (1993); the North American Free Trade Agreement Implementation Act, Pub. L. 103-182, 107 Stat. 2057 (1993) (codified as amended at 10 U.S.C.A. 2576) (1993) ("NAFTA Implementation Act"); and Executive Order 12889, "Implementation of the North American Free Trade Agreement," 58 FR 69681 (Dec. 30, 1993). However, on July 1, 2020, the Agreement between the United States of America, the United Mexican States, and the United Canadian States ("USMCA"), Nov. 30, 2018, 134 Stat. 11 (*i.e.*, the successor to NAFTA), went into effect, and Congress's action in replacing NAFTA through the USMCA Implementation Act, 19 U.S.C. 4501 *et seq*. (2020), implies the repeal of E.O. 12889 and its 75-day comment period requirement for technical regulations. Thus, the controlling laws are EPCA and the USMCA Implementation Act. Consistent with EPCA's public comment period requirements for consumer products, the USMCA only requires a minimum comment period of 60 days. Consequently, DOE now provides a 60-day public comment period for test procedure NOPRs.

Submitting comments via www.regulations.gov. The *www.regulations.gov* web page will require you to provide your name and contact information. Your contact information will be viewable to DOE Building Technologies staff only. Your contact information will not be publicly viewable except for your first and last names, organization name (if any), and submitter representative name (if any). If your comment is not processed properly because of technical difficulties, DOE will use this information to contact you. If DOE cannot read your comment due to technical difficulties and cannot contact you for clarification, DOE may not be able to consider your comment.

However, your contact information will be publicly viewable if you include it in the comment or in any documents attached to your comment. Any information that you do not want to be publicly viewable should not be included in your comment, nor in any document attached to your comment. Persons viewing comments will see only first and last names, organization names, correspondence containing comments, and any documents submitted with the comments.

Do not submit to *www.regulations.gov* information for which disclosure is restricted by statute, such as trade secrets and commercial or financial information (hereinafter referred to as Confidential Business Information ("CBI")). Comments submitted through *www.regulations.gov* cannot be claimed as CBI. Comments received through the website will waive any CBI claims for the information submitted. For information on submitting CBI, see the Confidential Business Information section.

DOE processes submissions made through *www.regulations.gov* before posting. Normally, comments will be posted within a few days of being submitted. However, if large volumes of comments are being processed simultaneously, your comment may not be viewable for up to several weeks. Please keep the comment tracking number that *www.regulations.gov* provides after you have successfully uploaded your comment.

Submitting comments via email. Comments and documents submitted via email also will be posted to *www.regulations.gov*. If you do not want your personal contact information to be publicly viewable, do not include it in your comment or any accompanying documents. Instead, provide your contact information on a cover letter. Include your first and last names, email address, telephone number, and optional mailing address. The cover letter will not be publicly viewable as long as it does not include any comments.

Include contact information each time you submit comments, data, documents, and other information to DOE. No faxes will be accepted.

Comments, data, and other information submitted to DOE electronically should be provided in PDF (preferred), Microsoft Word or Excel, WordPerfect, or text (ASCII) file format. Provide documents that are not secured, written in English and free of any defects or viruses. Documents should not contain special characters or any form of encryption and, if possible, they should carry the electronic signature of the author.

Campaign form letters. Please submit campaign form letters by the originating organization in batches of between 50 to 500 form letters per PDF or as one form letter with a list of supporters' names compiled into one or more PDFs. This reduces comment processing and posting time.

Confidential Business Information. Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email two well-marked copies: one copy of the document marked confidential including all the information believed to be confidential, and one copy of the document marked non-confidential with the information believed to be confidential deleted. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

It is DOE's policy that all comments may be included in the public docket, without change and as received, including any personal information provided in the comments (except information deemed to be exempt from public disclosure).

B. Issues on Which DOE Seeks Comment

Although DOE welcomes comments on any aspect of this proposal, DOE is particularly interested in receiving comments and views of interested parties concerning the following issues:

(1) DOE requests comment on its proposal to specify a reduced default fan power coefficient and default fan heat coefficient at part-load airflows in the calculations of SEER2 and HSPF2 for ducted two-stage coil-only systems. DOE requests comment on the specific default fan power coefficients and default fan heat coefficients proposed. If the proposed values are not appropriate, DOE seeks data to support selection of alternative values. Additionally, DOE requests comment on whether a single default fan power coefficient (and default fan heat coefficient) should be used for each product class group regardless of the actual air volume rate used for low-stage tests, or whether one of the alternative approaches discussed in the NOPR should be considered, or any other alternative. If an alternative approach should be

used, DOE requests details indicating how such an alternative should be implemented, and justification for its use rather than the proposed approach. See section III.B.1.

(2) DOE requests comment on its proposals related to test procedures for variable-speed coil-only CAC/HPs and on its proposed definitions for variable-speed communicating and non-communicating coil-only CAC/HPs. See section III.B.2.

(3) DOE requests comment on its proposal to clarify the language for required represented values of coil-only CACs found in the table at 10 CFR 429.16(a)(1). See section III.B.3.

(4) DOE requests comment on its planned approach to require the coil-only rating requirement for space-constrained air conditioners and heat pumps. DOE requests shipment and/or installation data for space-constrained systems to clarify the characteristics of representative installations. See section III.B.3.

(5) DOE requests comments on its proposal to add language clarifying how to implement variation of blower speed for different ambient temperature test conditions. See section III.C.1.

(6) DOE seeks comment on its proposal to amend the wet bulb temperature condition for the H4 heating tests from the existing 3°F maximum temperature to a maximum temperature of 4°F. See section III.C.2.

(7) DOE requests comment on the proposed alignment of the VRF and non-VRF test procedures when it comes to instruction precedence. See section III.C.3.

(8) DOE requests comment on its proposal to add more specific direction to step 7 of sections 3.1.4.1.1, 3.1.4.2, and 3.1.4.4.3. See section III.C.4.

(9) DOE requests comment on the proposed change to the full-capacity performance equations for variable-speed heat pumps in the ambient

temperature range above 45 ºF, adjusting the equations for capacity and power by the ratio of capacity and power, respectively, associated with H1N and H12 operation. See section III.C.5.

(10) DOE requests comment on its proposals to the regulatory text in 10 CFR part 429. See section III.D.1.

C. Participation in the Webinar

The time and date of the webinar are listed in the **DATES** section at the beginning of this document. If no participants register for the webinar, it will be cancelled.

Webinar registration information, participant instructions, and information about the capabilities available to webinar participants will be published on DOE's website: *https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=48&action=viewlive*. Participants are responsible for ensuring their systems are compatible with the webinar software. Procedure for Submitting Prepared General Statements for Distribution. Any person who has an interest in the topics addressed in this notice, or who is representative of a group or class of persons that has an interest in these issues, may request an opportunity to make an oral presentation at the webinar. Such persons may submit to *ApplianceStandardsQuestions@ee.doe.gov*. Persons who wish to speak should include with their request a computer file in WordPerfect, Microsoft Word, PDF, or text (ASCII) file format that briefly describes the nature of their interest in this rulemaking and the topics they wish to discuss. Such persons should also provide a daytime telephone number where they can be reached.

Persons requesting to speak should briefly describe the nature of their interest in this rulemaking and provide a telephone number for contact. DOE requests persons selected to make an oral presentation to submit an advance copy of their statements at least two weeks before the webinar. At its discretion, DOE may permit persons who cannot supply an advance copy of their statement to participate, if those persons have made advance alternative arrangements with the Building Technologies Office. As necessary, requests to give an oral presentation should ask for such alternative arrangements.

D. Conduct of the Webinar

DOE will designate a DOE official to preside at the webinar/public meeting and may also use a professional facilitator to aid discussion. The meeting will not be a judicial or evidentiary-type public hearing, but DOE will conduct it in accordance with section 336 of EPCA (42 U.S.C. 6306). A court reporter will be present to record the proceedings and prepare a transcript. DOE reserves the right to schedule the order of presentations and to establish the procedures governing the conduct of the webinar/public meeting. There shall not be discussion of proprietary information, costs or prices, market share, or other commercial matters regulated by U.S. anti-trust laws. After the webinar/public meeting and until the end of the comment period, interested parties may submit further comments on the proceedings and any aspect of the rulemaking.

The webinar/public meeting will be conducted in an informal, conference style. DOE will present a summary of the proposals, allow time for prepared general statements by participants, and encourage all interested parties to share their views on issues affecting this rulemaking. Each participant will be allowed to make a general statement (within time limits determined by DOE), before the discussion of specific topics. DOE will permit, as time permits, other participants to comment briefly on any general statements.

At the end of all prepared statements on a topic, DOE will permit participants to clarify their statements briefly. Participants should be prepared to answer questions by DOE and by other participants concerning these issues. DOE representatives may also ask questions of participants concerning other matters relevant to this rulemaking. The official conducting the webinar/public meeting will accept additional comments or questions from those attending, as time permits. The presiding official will announce any further procedural rules or modification of the above procedures that may be needed for the proper conduct of the webinar/public meeting.

A transcript of the webinar/public meeting will be included in the docket, which can be viewed as described in the Docket section at the beginning of this document. In addition, any person may buy a copy of the transcript from the transcribing reporter.

VI. Approval of the Office of the Secretary

The Secretary of Energy has approved publication of this proposed rule.

List of Subjects

10 CFR Part 429

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Intergovernmental relations, Reporting and recordkeeping requirements, Small businesses.

10 CFR Part 430

Administrative practice and procedure, Confidential business information, Energy conservation, Household appliances, Imports, Incorporation by reference, Intergovernmental relations, Small businesses.

Signing Authority

This document of the Department of Energy was signed on February 22, 2022, by Kelly J. Speakes-Backman, Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy, pursuant to delegated authority from the Secretary of Energy. That document with the original signature and date is maintained by DOE. For administrative purposes only, and in compliance with requirements of the Office of the Federal Register, the undersigned DOE Federal Register Liaison Officer has been authorized to sign and submit the document in electronic format for publication, as an official document of the Department of Energy. This administrative process in no way alters the legal effect of this document upon publication in the *Federal Register*.

Signed in Washington, DC, on February 24, 2022.

Treena V. Garrett
Federal Register Liaison Officer,
U.S. Department of Energy

For the reasons stated in the preamble, DOE is proposing to amend parts 429 and 430 of chapter II of title 10, Code of Federal Regulations as set forth below:

PART 429 – CERTIFICATION, COMPLIANCE, AND ENFORCEMENT FOR CONSUMER PRODUCTS AND COMMERCIAL AND INDUSTRIAL EQUIPMENT

1. The authority citation for part 429 continues to read as follows:

Authority: 42 U.S.C. 6291-6317; 28 U.S.C. 2461 note.

2. Section 429.16 is amended by:

a. Revising the table 1 to paragraph (a)(1);

b. Revising paragraph (a)(4)(i); and

c. Revising the table in paragraph (b)(2)(i).

The revisions read as follows:

§ 429.16 Central air conditioners and central air conditioning heat pumps

(a)* * *

(1) * * *

Table 1 to Paragraph (a)(1)

Category	Equipment Subcategory	Required Represented Values
Single-Package Unit	Single-Package AC (including space-constrained)	Every individual model distributed in commerce
	Single-Package HP (including space-constrained)	

Outdoor Unit and Indoor Unit (Distributed in Commerce by OUM)	Single-Split-System AC with Single-Stage or Two-Stage Compressor (including Space-Constrained and Small-Duct, High Velocity Systems (SDHV))	Every individual combination distributed in commerce. Each model of outdoor unit must include a represented value for at least one coil-only individual combination that is distributed in commerce and which is representative of the least efficient combination distributed in commerce with that particular model of outdoor unit. For that particular model of outdoor unit, additional represented values for coil-only and blower-coil individual combinations are allowed, if distributed in commerce.
	Single-Split System AC with Other Than Single-Stage or Two-Stage Compressor (including Space-Constrained and SDHV)	Every individual combination distributed in commerce, including all coil-only and blower-coil combinations
	Single-Split-System HP (including Space-Constrained and SDHV)	Every individual combination distributed in commerce.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System -- non-SDHV (including Space-Constrained)	For each model of outdoor unit, at a minimum, a non-ducted “tested combination.” For any model of outdoor unit also sold with models of ducted indoor units, a ducted “tested combination.” When determining represented values on or after January 1, 2023, the ducted “tested combination” must comprise the highest static variety of ducted indoor unit distributed in commerce (i.e., conventional, mid-static, or low-static). Additional representations are allowed, as described in paragraphs (c)(3)(i) and (c)(3)(ii) of this section, respectively.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System -- SDHV	For each model of outdoor unit, an SDHV “tested combination.” Additional representations are allowed, as described in paragraph (c)(3)(iii) of this section.

Indoor Unit Only Distributed in Commerce by ICM	Single-Split-System Air Conditioner (including Space-Constrained and SDHV)	Every individual combination distributed in commerce
	Single-Split-System Heat Pump (including Space-Constrained and SDHV)	
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System -- SDHV	For a model of indoor unit within each basic model, an SDHV "tested combination." Additional representations are allowed, as described in section (c)(3)(iii) of this section.
Outdoor Unit with no Match		Every model of outdoor unit distributed in commerce (tested with a model of coil-only indoor unit as specified in paragraph (b)(2)(i) of this section).

*   *   *   *   *

(4) *   *   *

(i) *Regional.* A basic model (model of outdoor unit) may only be certified as compliant with a regional standard if all individual combinations within that basic model meet the regional standard for which it is certified, including the coil-only combination as specified in paragraph (a)(1) of this section, as applicable. A model of outdoor unit that is certified below a regional standard can only be rated and certified as compliant with a regional standard if the model of outdoor unit has a unique model number and has been certified as a different basic model for distribution in each region, where the basic model(s) certified as compliant with a regional standard meet the requirements of the first sentence. An ICM cannot certify an individual combination with a rating that is compliant with a regional standard if the individual combination includes a model of outdoor unit that the OUM has certified with a rating that is not compliant with a regional standard. Conversely, an ICM cannot certify an individual combination with a rating that is not compliant with a regional standard if the individual combination includes a model of outdoor unit that an OUM has certified with a rating that is compliant with a regional standard.

* * * * *

(b) * * *

(2) * * *

(i) * * *

Table 2 to Paragraph (b)(2)(i)

Category	Equipment subcategory	Must test:	With:
Single-Package Unit	Single-Package AC (including Space-Constrained)	The individual model with the lowest SEER (when testing in accordance with appendix M to subpart B of part 430) or SEER2 (when testing in accordance with appendix M1 to subpart B of part 430)	N/A.
	Single-Package HP (including Space-Constrained)		
Outdoor Unit and Indoor Unit (Distributed in Commerce by OUM)	Single-Split-System AC with Single-Stage or Two-Stage Compressor (including Space-Constrained and Small- Duct, High Velocity Systems (SDHV))	The model of outdoor unit	A model of coil-only indoor unit.
	Single-Split-System HP with Single-Stage or Two-Stage Compressor (including Space-Constrained and SDHV)	The model of outdoor unit	A model of indoor unit.
	Single-Split System AC or HP with Other Than Single-Stage or Two-Stage	The model of outdoor unit	A model of coil-only indoor unit. If the outdoor unit is distributed in

	Compressor having a coil-only individual combination (including Space-Constrained and SDHV)		commerce in a non-communicating variable-speed coil-only combination, the tested combination must be non-communicating.
	Single-Split System AC or HP with Other Than Single-Stage or Two-Stage Compressor without a coil-only individual combination (including Space-Constrained and SDHV)	The model of outdoor unit	A model of indoor unit.
	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System - non-SDHV (including Space-Constrained)	The model of outdoor unit	At a minimum, a “tested combination” composed entirely of non-ducted indoor units. For any models of outdoor units also sold with models of ducted indoor units, test a second “tested combination” composed entirely of ducted indoor units (in addition to the non-ducted combination). If testing under appendix M1 to subpart B of part 430, the ducted “tested combination” must comprise the highest static variety of ducted indoor unit distributed in commerce (i.e., conventional, mid-static, or low-static).

	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System - SDHV	The model of outdoor unit	A "tested combination" composed entirely of SDHV indoor units.
Indoor Unit Only (Distributed in Commerce by ICM)	Single-Split-System Air Conditioner (including Space-Constrained and SDHV)	A model of indoor unit	The least efficient model of outdoor unit with which it will be paired where the least efficient model of outdoor unit is the model of outdoor unit in the lowest SEER combination (when testing under appendix M to subpart B of part 430) or SEER2 combination (when testing under appendix M1 to subpart B of part 430) as certified by the OUM. If there are multiple models of outdoor unit with the same lowest SEER (when testing under appendix M to subpart B of part 430) or SEER2 (when testing under appendix M1 to subpart B of part 430) represented value, the ICM may select one for testing purposes.
	Single-Split-System Heat Pump (including Space-Constrained and SDHV)	Nothing, as long as an equivalent air conditioner basic model has been tested If an equivalent air conditioner basic model has not been tested, must test a model of indoor unit	

	Multi-Split, Multi-Circuit, or Multi-Head Mini-Split Split System - SDHV	A model of indoor unit	A "tested combination" composed entirely of SDHV indoor units, where the outdoor unit is the least efficient model of outdoor unit with which the SDHV indoor unit will be paired. The least efficient model of outdoor unit is the model of outdoor unit in the lowest SEER combination (when testing under appendix M to subpart B of part 430) or SEER2 combination (when testing under appendix M1 to subpart B of part 430) as certified by the OUM. If there are multiple models of outdoor unit with the same lowest SEER represented value (when testing under appendix M to subpart B of part 430) or SEER2 represented value (when testing under appendix M1 to subpart B of part 430), the ICM may select one for testing purposes.
Outdoor Unit with No Match		The model of outdoor unit	A model of coil-only indoor unit meeting the requirements of section 2.2e of appendix M or M1 to subpart B of part 430.

3. Section 429.102 is amended by revising paragraphs (c)(4)(i) and (iii) to read as follows:

§ 429.102 Prohibited acts subjecting persons to enforcement action

* * * * *

(c) * * *

(4) * * *

(i) A complete central air conditioning system that is not certified as a complete system that meets the applicable standard. Combinations that were previously validly certified may be installed after the manufacturer has discontinued the combination, provided all combinations within the basic model, including for single-split-system AC with single-stage or two-stage compressor at least one coil-only combination as specified in paragraph (a)(1) of this section, comply with the regional standard applicable at the time of installation.

* * * * *

(iii) An outdoor unit that is part of a certified combination rated less than the standard applicable in the region in which it is installed or, where applicable, an outdoor unit with no certified coil-only combination as specified in paragraph (a)(1) of this section that meets the standard applicable in the region in which it is installed.

§ 429.158 [Amended]

4. Section 429.158 is amended by removing "§429.102(c)" in paragraphs (a) and (b) and adding in its place "§429.102(b)(10)".

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5. The authority citation for part 430 continues to read as follows:

Authority: 42 U.S.C. 6291-6309; 28 U.S.C. 2461 note.

6. Section 430.2 is amended by revising the definition for "Central air conditioner or central air conditioning heat pump" to read as follows:

§ 430. 2 Definitions.

* * * * *

Central air conditioner or central air conditioning heat pump means a product, other than a packaged terminal air conditioner, packaged terminal heat pump, single-phase single-package vertical air conditioner with cooling capacity less than 65,000 Btu/h, single-phase single-package vertical heat pump with cooling capacity less than 65,000 Btu/h, computer room air conditioner, or unitary dedicated outdoor air system as these equipment categories are defined at 10 CFR 431.92, which is powered by single phase electric current, air cooled, rated below 65,000 Btu per hour, not contained within the same cabinet as a furnace, the rated capacity of which is above 225,000 Btu per hour, and is a heat pump or a cooling unit only. A central air conditioner or central air conditioning heat pump may consist of: A single-package unit; an outdoor unit and one or more indoor units; an indoor unit only; or an outdoor unit with no match. In the case of an indoor unit only or an outdoor unit with no match, the unit must be tested and rated as a system (combination of both an indoor and an outdoor unit). For all central air conditioner and central air conditioning heat pump-related definitions, see appendix M or M1 of subpart B of this part.

* * * * *

7. Section 430.32 is amended by revising paragraph (c)(6)(ii) to read as follows:

§ 430.32 Energy and water conservation standards and their compliance dates.

*   *   *   *   *

(c)   *   *   *

(6)   *   *   *

(ii) Any model of outdoor unit that has a certified combination with a rating below the applicable standard level(s) for a region cannot be installed in that region. The least-efficient combination of each basic model, which for single-split-system AC with single-stage or two-stage compressor (including Space-Constrained and Small-Duct High Velocity Systems (SDHV)) must be a coil-only combination, must comply with the applicable standard. See 10 CFR 429.16(a)(1) and (a)(4)(i) of this chapter.

*   *   *   *   *

8. Appendix M to subpart B of part 430 is amended by:

a. Revising the definition of “Nominal Capacity” in section 1.2;

b. Revising paragraph a of section 3.6.4;

c. Revising section 4.1.4.2;

d. Revising the introductory text to section 4.2.3;

e. Revising the equation following the word “Where:” in section 4.2.3.3; and

f. Revising section 4.2.3.4.

The revisions read as follows:

Appendix M to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps

*   *   *   *   *

1.   *   *   *

1.2   *   *   *

Nominal Cooling Capacity is approximate to the air conditioner cooling capacity tested at A or A_2 condition. Nominal heating capacity is approximate to the heat pump heating capacity tested in H1N test.

* * * * *

3. * * *

3.6.4 * * *

a. Conduct one maximum temperature test ($H0_1$), two high temperature tests ($H1_N$ and $H1_1$), one frost accumulation test ($H2_V$), and one low temperature test ($H3_2$). Conducting one or both of the following tests is optional: An additional high temperature test ($H1_2$) and an additional frost accumulation test ($H2_2$). If desired, conduct the optional maximum temperature cyclic ($H0C_1$) test to determine the heating mode cyclic-degradation coefficient, C_D^h. If this optional test is conducted but yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. Test conditions for the eight tests are specified in Table 14. The compressor shall operate at the same heating full speed, measured by RPM or power input frequency (Hz), for the $H1_2$, $H2_2$ and $H3_2$ tests. For a cooling/heating heat pump, the compressor shall operate for the $H1_N$ test at a speed, measured by RPM or power input frequency (Hz), no lower than the speed used in the A_2 test if the tested $H1_N$ heating capacity is less than the tested A_2 cooling capacity. The compressor shall operate at the same heating minimum speed, measured by RPM or power input frequency (Hz), for the $H0_1$, $H1C_1$, and $H1_1$ tests. Determine the heating intermediate compressor speed cited in Table 14 using the heating mode full and minimum compressors speeds and:

$$Heating\ intermediate\ speed = Heating\ minimum\ speed + \frac{Heating\ full\ speed - Heating\ minimum\ speed}{3}$$

Where a tolerance on speed of plus 5 percent or the next higher inverter frequency step from the calculated value is allowed.

* * * * *

4. * * *

4.1.4.2 Unit Operates at an Intermediate Compressor Speed (k=i) In Order To Match the Building Cooling Load at Temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

$$\frac{q_c(T_j)}{N} = \dot{Q}_c^{k=i}(T_j) * \frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = \dot{E}_c^{k=i}(T_j) * \frac{n_j}{N}$$

where:

$\dot{Q}_c^{k=i}(T_j) = BL(T_j)$, the space cooling capacity delivered by the unit in matching the building load at temperature T_j, Btu/h. The matching occurs with the unit operating at compressor speed k=i.

$\dot{E}_c^{k=i}(T_j) = \frac{\dot{Q}_c^{k=i}(T_j)}{EER^{k=i}(T_j)}$, the electrical power input required by the test unit when operating at a compressor speed of k=i and temperature T_j, W.

$EER^{k=i}(T_j)$ = the steady-state energy efficiency ratio of the test unit when operating at a compressor speed of k=i and temperature T_j, Btu/h per W.

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 19. For each temperature bin where the unit operates at an intermediate compressor speed, determine the energy efficiency ratio $EER^{k=i}(T_j)$ using,

$EER^{k=i}(T_j) = A + B * T_j + C * T_j^2$.

For each unit, determine the coefficients A, B, and C by conducting the following calculations once:

$$A = EER^{k=2}(T_2) - (B * T_2) - (C * T_2^2)$$

$$B = \frac{EER^{k=1}(T_1) - EER^{k=2}(T_2) - D * [EER^{k=1}(T_1) - EER^{k=v}(T_v)]}{T_1 - T_2 - D * (T_1 - T_v)}$$

$$C = \frac{EER^{k=1}(T_1) - EER^{k=2}(T_2) - B * (T_1 - T_2)}{T_1^2 - T_2^2}$$

$$D = \frac{T_2^2 - T_1^2}{T_v^2 - T_1^2}$$

where:

T_1 = the outdoor temperature at which the unit, when operating at minimum compressor speed, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=l}(T_l)$ = $BL(T_1)$), °F. Determine T_1 by equating Equations 4.1.3-1 and 4.1-2 and solving for outdoor temperature.

T_v = the outdoor temperature at which the unit, when operating at the intermediate compressor speed used during the section 3.2.4 E_v test of this appendix, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=v}(T_v) = BL(T_v)$), °F. Determine T_v by equating Equations 4.1.4-3 and 4.1-2 and solving for outdoor temperature.

T_2 = the outdoor temperature at which the unit, when operating at full compressor speed, provides a space cooling capacity that is equal to the building load ($\dot{Q}_c^{k=2}(T_2) = BL(T_2)$), °F. Determine T_2 by equating Equations 4.1.3-3 and 4.1-2 and solving for outdoor temperature.

$$EER^{k=1}(T_1) = \frac{\dot{Q}_c^{k=1}(T_1)\ [Equation\ 4.1.4-1, substituting\ T_1\ for\ T_j]}{\dot{E}_c^{k=1}(T_1)\ [Equation\ 4.1.4-2, substituting\ T_1\ for\ T_j]}, \text{ Btu/h per W}$$

$$EER^{k=v}(T_v) = \frac{\dot{Q}_c^{k=v}(T_v)\ [Equation\ 4.1.4-3, substituting\ T_v\ for\ T_j]}{\dot{E}_c^{k=v}(T_v)\ [Equation\ 4.1.4-4, substituting\ T_v\ for\ T_j]}, \text{ Btu/h per W}$$

$$EER^{k=2}(T_2) = \frac{\dot{Q}_c^{k=2}(T_2)\ [Equation\ 4.1.3-3, substituting\ T_2\ for\ T_j]}{\dot{E}_c^{k=2}(T_2)\ [Equation\ 4.1.3-4, substituting\ T_2\ for\ T_j]}, \text{ Btu/h per W}$$

*` * * * *

4.2. * * *

4.2.3

Additional Steps for Calculating the HSPF of a Heat Pump Having a Two-Capacity Compressor

The calculation of the Equation 4.2-1 quantities differ depending upon whether the heat pump would operate at low capacity (section 4.2.3.1 of this appendix), cycle between low and high capacity (section 4.2.3.2 of this appendix), or operate at high capacity (sections 4.2.3.3 and 4.2.3.4 of this appendix) in responding to the building load. For heat pumps that lock out low capacity operation at low outdoor temperatures, the outdoor temperature at which the unit locks out must be that specified by the manufacturer in the certification report so that the appropriate equations can be selected.

*   *   *   *   *

4.2.3.3 Heat Pump Only Operates at High (k=2) Compressor Capacity at Temperature T_j and its Capacity Is Greater Than the Building Heating Load, $BL(T_j) < Q_h^{k=2}(T_j)$

*   *   *   *   *

$X^{k=2}(T_j) = BL(T_j)/\dot{Q}_h^{k=2}(T_j)$; and

$PLF_j = 1 - C_D^{h\,(k=2)} * [1 - X^{k=2}(T_j)].^{()}()$

*   *   *   *   *

4.2.3.4 Heat Pump Must Operate Continuously at High (k=2) Compressor Capacity at Temperature T_j, $BL(T_j) \geq \dot{Q}_h^{k=2}(T_j)$

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=2}(T_j) * \delta'(T_j) * \frac{n_j}{N}$$

$$\frac{RH(T_j)}{N} = \frac{BL(T_j) - [\dot{Q}_h^{k=2}(T_j) * \delta'(T_j)]}{3.413\,\frac{Btu}{Wh}} * \frac{n_j}{N}$$

where:

$$\delta'(T_j) = \begin{cases} 0, & if\ T_j \leq T_{off}\ or\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} < 1 \\ \dfrac{1}{2}, & if\ T_{off} < T_j \leq T_{on}\ and\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} \geq 1 \\ 1, & if\ T_j > T_{on}\ and\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} \geq 1 \end{cases}$$

* * * * *

9. Appendix M1 to subpart B of part 430 is amended by:

a. Adding in alphabetical order definitions for "Variable-speed Communicating Coil-only Central Air Conditioner or Heat Pump" and "Variable-speed Non-communicating Coil-only Central Air Conditioner or Heat Pump" in section 1.2;

b. Revising paragraph (B) and the undesignated paragraph following it in section 2;

c. Revising section 3.1.2;

d. Revising paragraphs a. and b. in section 3.1.4.1.1;

e. Revising paragraphs a. and b. and adding paragraph f in section 3.1.4.2:

f. Revising paragraph b. and adding paragraph d. in section 3.1.4.3;

g. Revising paragraph a. in section 3.1.4.4.3;

h. Adding paragraph d. in section 3.1.4.6;

i. Revising section 3.1.4.7;

j. Revising paragraph a., adding paragraph d., and revising Table 8 in section 3.2.4;

k. Revising paragraph d., redesignating paragraph e. as paragraph f., and adding a new paragraph e. in section 3.3;

l. Revising the introductory text, redesignating paragraphs a. and b. as c. and d., respectively, adding new paragraphs a. and b., and revising newly redesignated paragraph c. in section 3.5.1;

m. Revising Table 11 in section 3.6.1;

n. Revising Table 12 in section 3.6.2;

o. Revising Table 13 in section 3.6.3

p. Revising section 3.6.4 and adding sections 3.6.4.1 and 3.6.4.2.;

q. Revising Table 15 in section 3.6.6;

r. Revising paragraph c., redesignating paragraphs d. and e. as e. and f., respectively, and adding new paragraph d. in section 3.7;

s. Revising paragraph b. in section 3.8;

t. Revising paragraph b. in section 3.9.1;

u. Revising section 4.1.4;

v. Adding sections 4.1.4.2.1 and 4.1.4.2.2;

w. Revising the language after "Table 20" and before paragraph a., including Equation 4.2-2, in section 4.2;

x. Revising the introductory text for section 4.2.3.;

y. Revising section 4.2.3.4;

z. Revising paragraphs a., b., c., and e., in section 4.2.4;

aa. Revising sections 4.2.4.1 and 4.2.4.2; and

bb. Removing the language "and $X^{k=3}(T_j) = X^{k=2}(T_j)$" and adding in its place "and $X^{k=3}(T_j) = 1- X^{k=2}(T_j)$," in section 4.2.6.5.

The revisions and additions read as follows:

Appendix M1 to Subpart B of Part 430—Uniform Test Method for Measuring the Energy Consumption of Central Air Conditioners and Heat Pumps

* * * *

1.2 * * *

Variable-speed Communicating Coil-only Central Air Conditioner or Heat Pump means a variable-speed compressor system having a coil-only indoor unit that is installed with a control system that:

(a) Communicates the difference in space temperature and space setpoint temperature (not a setpoint value inferred from on/off thermostat signals) to the control that sets compressor speed;

(b) Provides a signal to the indoor fan to set fan speed appropriate for compressor staging; and

(c) Has installation instructions indicating that the control system having these capabilities must be installed.

* * * * *

Variable-speed Non-communicating Coil-only Central Air Conditioner or Heat Pump means a variable-speed compressor system having a coil-only indoor unit that is does not meet the definition of variable-speed communicating coil-only central air conditioner or heat pump.

* * * * *

2 * * *

(B) For systems other than VRF, only a subset of the sections listed in this test procedure apply when testing and determining represented values for a particular unit. Table 1 shows the sections of the test procedure that apply to each system. This table is meant to assist manufacturers in finding the appropriate sections of the test procedure.

Manufacturers are responsible for determining which sections apply to each unit tested based on the model characteristics. The appendix sections provide the specific requirements for testing. To use Table 1, first refer to the sections listed under “all units”. Then refer to additional requirements based on:

(1) System configuration(s),

(2) The compressor staging or modulation capability, and

(3) Any special features.

Testing requirements for space-constrained products do not differ from similar products that are not space-constrained, and thus space-constrained products are not listed separately in this table. Air conditioners and heat pumps are not listed separately in this table, but heating procedures and calculations apply only to heat pumps.

The “manufacturer’s published instructions,” as stated in section 8.2 of ASHRAE Standard 37-2009 (incorporated by reference, see §430.3) and “manufacturer’s installation instructions” discussed in this appendix mean the manufacturer’s installation instructions that come packaged with the unit or appear in the labels applied to the unit. Manufacturer’s installation instructions do not include online manuals. Installation instructions that appear in the labels applied to the unit shall take precedence over installation instructions that come packaged with the unit.

* * * * *

3.1.2 Manufacturer-Provided Equipment Overrides

Where needed, the manufacturer must provide a means for overriding the controls of the test unit so that the compressor(s) operates at the specified speed or capacity and the indoor blower operates at the specified speed or delivers the specified air volume rate. For variable-speed non-communicating coil-only air conditioners and heat pumps, the control system shall be provided with a control signal indicating operation at high or low stage, rather than testing with the compressor speed fixed at specific speeds, with the exception that compressor speed override may be used for heating mode test $H1_2$.

*   *   *   *   *

3.1.4.1.1   *   *   *

a. For all ducted blower coil systems, except those having a constant-air-volume-rate indoor blower:

Step (1) Operate the unit under conditions specified for the A test (for single-stage units) or A_2 test (for non-single-stage units) using the certified fan speed or controls settings, and adjust the exhaust fan of the airflow measuring apparatus to achieve the certified Cooling full-load air volume rate;

Step (2) Measure the external static pressure;

Step (3) If this external static pressure is equal to or greater than the applicable minimum external static pressure cited in Table 4, the pressure requirement is satisfied; proceed to step 7 of this section. If this external static pressure is not equal to or greater than the applicable minimum external static pressure cited in Table 4, proceed to step 4 of this section;

Step (4) Increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until the first to occur of:

(i) The applicable Table 4 minimum is equaled or

(ii) The measured air volume rate equals 90 percent or less of the Cooling full-load air volume rate;

Step (5) If the conditions of step 4 (i) of this section occur first, the pressure requirement is satisfied; proceed to step 7 of this section. If the conditions of step 4 (ii) of this section occur first, proceed to step 6 of this section;

Step (6) Make an incremental change to the setup of the indoor blower (e.g., next highest fan motor pin setting, next highest fan motor speed) and repeat the evaluation process beginning above, at step 1 of this section. If the indoor blower setup cannot be further changed, increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until the applicable Table 4 minimum is equaled; proceed to step 7 of this section;

Step (7) The airflow constraints have been satisfied. Use the measured air volume rate as the Cooling full-load air volume rate. Use the final indoor fan speed or control settings of the unit under test for all tests that use the Cooling full-load air volume rate. Adjust the fan of the airflow measurement apparatus if needed to obtain the same full-load air volume rate (in scfm) for all such tests, unless the system modulates indoor blower speed with outdoor dry bulb temperature or to adjust the sensible to total cooling capacity ratio—in this case, use an air volume rate that represents a normal installation and calculate the target external static pressure as described in section 3.1.4.2 of this appendix.

b. For ducted blower coil systems with a constant-air-volume-rate indoor blower. For all tests that specify the Cooling full-load air volume rate, obtain an external static pressure as close to (but not less than) the applicable Table 4 value that does not cause either automatic shutdown of the indoor blower or a value of air volume rate variation Q_{Var}, defined as follows, that is greater than 10 percent.

$$Q_{var} = \left[\frac{Q_{max} - Q_{min}}{\left(\frac{Q_{max} + Q_{min}}{2}\right)}\right] * 100$$

Where:

Q_{max} = maximum measured airflow value

Q_{min} = minimum measured airflow value

Q_{Var} = airflow variance, percent

Additional test steps as described in section 3.3.f of this appendix are required if the measured external static pressure exceeds the target value by more than 0.03 inches of water.

*　　*　　*　　*　　*

3.1.4.2 *　　*　　*

a. For a ducted blower coil system without a constant-air-volume indoor blower, adjust for external static pressure as follows:

Step (1) Operate the unit under conditions specified for the B_1 test using the certified fan speed or controls settings, and adjust the exhaust fan of the airflow measuring apparatus to achieve the certified cooling minimum air volume rate;

Step (2) Measure the external static pressure;

Step (3) If this pressure is equal to or greater than the minimum external static pressure computed above, the pressure requirement is satisfied; proceed to step 7 of this section. If this pressure is not equal to or greater than the minimum external static pressure computed above, proceed to step 4 of this section;

Step (4) Increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until either:

(i) The pressure is equal to the minimum external static pressure, ΔP_{st_i}, computed above or

(ii) The measured air volume rate equals 90 percent or less of the cooling minimum air volume rate, whichever occurs first;

Step (5) If the conditions of step 4 (i) of this section occur first, the pressure requirement is satisfied; proceed to step 7 of this section. If the conditions of step 4 (ii) of this section occur first, proceed to step 6 of this section;

Step (6) Make an incremental change to the setup of the indoor blower (e.g., next highest fan motor pin setting, next highest fan motor speed) and repeat the evaluation process beginning above, at step 1 of this section. If the indoor blower setup cannot be further changed, increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until it equals the minimum external static pressure computed above; proceed to step 7 of this section;

Step (7) The airflow constraints have been satisfied. Use the measured air volume rate as the cooling minimum air volume rate. Use the final indoor fan speed or control settings of the unit under test for all tests that use the cooling minimum air volume rate. Adjust the fan of the airflow measurement apparatus if needed to obtain the same cooling minimum air volume rate (in scfm) for all such tests, unless the system modulates the indoor blower speed with outdoor dry bulb temperature or to adjust the sensible to total cooling capacity ratio—in this case, use an air volume rate that represents a normal installation and calculate the target minimum external static pressure as described in this section 3.1.4.2.

b. For ducted units with constant-air-volume indoor blowers, conduct all tests that specify the cooling minimum air volume rate—(*i.e.,* the A_1, B_1, C_1, F_1, and G_1 Tests)—at an external static pressure that does not cause either an automatic shutdown of the indoor blower or a value of air volume rate variation Q_{Var}, defined in section 3.1.4.1.1.b of this appendix, that is greater than 10 percent, while being as close to, but not less than the target minimum external static pressure. Additional test steps as described in section 3.3.f of this appendix are required if the measured external static pressure exceeds the target value by more than 0.03 inches of water.

*   *   *   *   *

f. For ducted variable-speed compressor systems tested with a coil-only indoor unit, the cooling minimum air volume rate is the higher of:

(1) The rate specified by the installation instructions included with the unit by the manufacturer; or

(2) 75 percent of the cooling full-load air volume rate. During the laboratory tests on a coil-only (fanless) system, obtain this cooling minimum air volume rate regardless of the pressure drop across the indoor coil assembly.

* * * * *

3.1.4.3 * * *

b. For a ducted blower coil system with a constant-air-volume indoor blower, conduct the E_V Test at an external static pressure that does not cause either an automatic shutdown of the indoor blower or a value of air volume rate variation Q_{Var}, defined in section 3.1.4.1.1.b of this appendix, that is greater than 10 percent, while being as close to, but not less than the target minimum external static pressure. Additional test steps as described in section 3.3.f of this appendix are required if the measured external static pressure exceeds the target value by more than 0.03 inches of water.

* * * * *

d. For ducted variable-speed compressor systems tested with a coil-only indoor unit, use the cooling minimum air volume rate as determined in section 3.1.4.2(f) of this appendix, without regard to the pressure drop across the indoor coil assembly.

* * * * *

3.1.4.4.3 * * *

a. For all ducted heating-only blower coil system heat pumps, except those having a constant-air-volume-rate indoor blower: conduct the following steps only during the first test, the H1 or $H1_2$ test:

Step (1) Adjust the exhaust fan of the airflow measuring apparatus to achieve the certified heating full-load air volume rate.

Step (2) Measure the external static pressure.

Step (3) If this pressure is equal to or greater than the Table 4 minimum external static pressure that applies given the heating-only heat pump's rated heating capacity, the pressure requirement is satisfied; proceed to step 7 of this section. If this pressure is not equal to or greater than the applicable Table 4 minimum external static pressure, proceed to step 4 of this section;

Step (4) Increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until either:

(i) The pressure is equal to the applicable Table 4 minimum external static pressure; or

(ii) The measured air volume rate equals 90 percent or less of the heating full-load air volume rate, whichever occurs first;

Step (5) If the conditions of step 4 (i) of this section occur first, the pressure requirement is satisfied; proceed to step 7 of this section. If the conditions of step 4 (ii) of this section occur first, proceed to step 6 of this section;

Step (6) Make an incremental change to the setup of the indoor blower (e.g., next highest fan motor pin setting, next highest fan motor speed) and repeat the evaluation process beginning above, at step 1 of this section. If the indoor blower setup cannot be further changed, increase the external static pressure by adjusting the exhaust fan of the airflow measuring apparatus until it equals the applicable Table 4 minimum external static pressure; proceed to step 7 of this section;

Step (7) The airflow constraints have been satisfied. Use the measured air volume rate as the heating full-load air volume rate. Use the final indoor fan speed or control settings of the unit under test for all tests that use the heating full-load air volume rate. Adjust the fan of the airflow measurement apparatus if needed to obtain the same heating full-load air volume rate (in scfm) for all such tests, unless the system modulates indoor blower speed with outdoor dry bulb temperature—in this case, use an air volume rate that represents a normal installation and calculate the target minimum external static pressure as described in section 3.1.4.2 of this appendix.

*   *   *   *   *

3.1.4.6 *   *   *

d. For ducted variable-speed compressor systems tested with a coil-only indoor unit, use the heating minimum air volume rate, which (as specified in section 3.1.4.5.1.a.(3) of this appendix) is equal to the cooling minimum air volume rate, without regard to the pressure drop across the indoor coil assembly.

*   *   *   *   *

3.1.4.7 Heating Nominal Air Volume Rate

The manufacturer must specify the heating nominal air volume rate and the instructions for setting fan speed or controls. Calculate target minimum external static pressure as described in section 3.1.4.2 of this appendix. Make adjustments as described in section 3.1.4.6 of this appendix for heating intermediate air volume rate so that the target minimum external static pressure is met or exceeded. For ducted variable-speed compressor systems tested with a coil-only indoor unit, use the heating full-load air volume rate as the heating nominal air volume rate.

*   *   *   *   *

3.2.4 *   *   *

a. Conduct five steady-state wet coil tests: the A_2, E_V, B_2, B_1, and F_1 Tests (the E_V test is not applicable for variable speed non-communicating coil-only air conditioners and heat pumps). Use the two optional dry-coil tests, the steady-state G_1 Test and the cyclic I_1 Test, to determine the cooling mode cyclic degradation coefficient, C_D^c. If the two optional tests are conducted and yield a tested C_D^c that exceeds the default C_D^c or if the two optional tests are not conducted, assign C_D^c the default value of 0.25. Table 8 specifies test conditions for these seven tests. The compressor shall operate at the same cooling full speed, measured by RPM or power input frequency (Hz), for both the A_2 and B_2 tests. The compressor shall operate at the same cooling minimum speed, measured by

RPM or power input frequency (Hz), for the B_1, F_1, G_1, and I_1 tests. Determine the cooling intermediate compressor speed cited in Table 8, as required, using:

$$\text{Cooling intermediate speed} = \text{Cooling minimum speed} + \frac{\text{Cooling full speed} - \text{Cooling minimum speed}}{3}$$

where a tolerance of plus 5 percent or the next higher inverter frequency step from that calculated is allowed.

* * * *

d. For variable-speed non-communicating coil-only air conditioners and heat pumps, the manufacturer-provided equipment overrides for full and minimum compressor speed described in section 3.1.2 of appendix M1 shall be limited to two stages of digital on/off control.

Table 8 Cooling Mode Test Condition for Units Having a Variable-Speed Compressor

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Cooling air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
A_2 Test—required (steady, wet coil)	80	67	95	[1]75	Cooling Full	Cooling Full-Load[2]
B_2 Test—required (steady, wet coil)	80	67	82	[1]65	Cooling Full	Cooling Full-Load[2]
E_V Test—required[7] (steady, wet coil)	80	67	87	[1]69	Cooling Intermediate	Cooling Intermediate[3]
B_1 Test—required (steady, wet coil)	80	67	82	[1]65	Cooling Minimum	Cooling Minimum[4]
F_1 Test—required (steady, wet coil)	80	67	67	[1]53.5	Cooling Minimum	Cooling Minimum[4]

G_1 Test[5]—optional (steady, dry-coil)	80	([6])	67		Cooling Minimum	Cooling Minimum[4]
I_1 Test[5]—optional (cyclic, dry-coil)	80	([6])	67		Cooling Minimum	([6])

[1]The specified test condition only applies if the unit rejects condensate to the outdoor coil.

[2]Defined in section 3.1.4.1 of this appendix.

[3]Defined in section 3.1.4.3 of this appendix.

[4]Defined in section 3.1.4.2 of this appendix.

[5]The entering air must have a low enough moisture content so no condensate forms on the indoor coil. DOE recommends using an indoor air wet bulb temperature of 57 °F or less.

[6]Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure difference or velocity pressure as measured during the G_1 Test.

[7]The E_V test is not applicable for variable-speed non-communicating coil-only air conditioners and heat pumps.

* * * * *

3.3 * * *

d. For mobile home and space-constrained ducted coil-only system tests,

(1) For two-stage or variable-speed systems, for all steady-state wet coil tests that specify the cooling minimum air volume rate or cooling intermediate air volume rate (*i.e.*, the A_1, B_1 , E_V, and F_1 tests) and for which the minimum or intermediate air volume rate is 75 percent of the cooling full-load air volume rate:

decrease $Q_c{}^k(T)$ by: $\frac{1130\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{331\ W}{1000\ scfm} * \dot{V}_S$

(2) For two-stage or variable-speed systems, for all steady-state wet coil tests that specify the cooling full-load air volume rate (*i.e.,* the A_2 and B_2 tests) or tests using a

minimum or intermediate air volume rate that is greater than 75 percent of the cooling full-load air volume rate:

decrease $Q_c{}^k(T)$ by: $\frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{406\ W}{1000\ scfm} * \dot{V}_S$

(3) For single-stage systems, for all steady-state wet coil tests (*i.e.,* the A and B tests) –

decrease $Q_c{}^k(T)$ by: $\frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{406\ W}{1000\ scfm} * \dot{V}_S$

where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

e. For non-mobile, non-space-constrained home ducted coil-only system tests,

(1) For two-stage or variable-speed systems, for all steady-state wet coil tests that specify the cooling minimum air volume rate or cooling intermediate air volume rate (*i.e.*, the A_1, B_1 , E_V, and F_1 tests) and for which the minimum or intermediate air volume rate is 75 percent of the cooling full-load air volume rate:

decrease $Q_c{}^k(T)$ by: $\frac{1228\ Btu/h}{1000\ scfm} * \dot{V}_S$, and increase $\dot{E}_c^k(T)$ by: $\frac{360\ W}{1000\ scfm} * \dot{V}_S$

(2) For two-stage or variable-speed systems, for all steady-state wet coil tests that specify the cooling full-load air volume rate (*i.e.,* the A_2 and B_2 tests) or tests using a minimum or intermediate air volume rate that is greater than 75 percent of the cooling full-load air volume rate:

decrease $Q_c^k(T)$ by: $\frac{1505\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c^k(T)$ by: $\frac{441\ W}{1000\ scfm} * \dot{V}_S$

(3) For single-stage systems, for all steady-state wet coil tests (*i.e.,* the A and B tests) –

decrease $Q_c^k(T)$ by: $\frac{1505\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c^k(T)$ by: $\frac{441\ W}{1000\ scfm} * \dot{V}_S$

where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

Table 9—Test Operating and Test Condition Tolerances for Section 3.3 Steady-State Wet Coil Cooling Mode Tests and Section 3.4 Dry Coil Cooling Mode Tests

	Test operating tolerance[1]	Test condition tolerance[1]
Indoor dry-bulb, °F		
Entering temperature	2.0	0.5
Leaving temperature	2.0	

Indoor wet-bulb, °F		
Entering temperature	1.0	[2]0.3
Leaving temperature	[2]1.0	
Outdoor dry-bulb, °F		
Entering temperature	2.0	0.5
Leaving temperature	[3]2.0	
Outdoor wet-bulb, °F		
Entering temperature	1.0	[4]0.3
Leaving temperature	[3]1.0	
External resistance to airflow, inches of water	0.05	[5]0.02
Electrical voltage, % of reading.	2.0	1.5
Nozzle pressure drop, % of reading.	2.0	

[1]See section 1.2 of this appendix, Definitions.

[2]Only applies during wet coil tests; does not apply during steady-state, dry coil cooling mode tests.

[3]Only applies when using the outdoor air enthalpy method.

[4]Only applies during wet coil cooling mode tests where the unit rejects condensate to the outdoor coil.

[5]Only applies when testing non-ducted units.

* * * * *

3.5.1 * * *

The automatic controls that are installed in the test unit must govern the OFF/ON cycling of the air moving equipment on the indoor side (*i.e.* the exhaust fan of the airflow measuring apparatus and the indoor blower of the test unit). For ducted coil-only systems rated based on using a fan time-delay relay, control the indoor coil airflow according to the OFF delay listed by the manufacturer in the certification report. For ducted units having a variable-speed indoor blower that has been disabled (and possibly removed), start and stop the indoor airflow at the same instances as if the fan were enabled. For all other ducted coil-only systems, cycle the indoor coil airflow in unison with the cycling of the compressor. If air damper boxes are used, close them on the inlet and outlet side during the OFF period. Airflow through the indoor coil should stop within 3 seconds after the automatic controls of the test unit de-energize (or if the airflow system has been disabled (and possibly removed), within 3 seconds after the automatic controls of the test unit *would have* de-energized) the indoor blower.

a. For mobile home and space-constrained ducted coil-only systems,

(1) For two-stage or variable-speed systems, for all cyclic dry-coil tests that specify the cooling minimum air volume rate (*i.e.,* the D_1 and I_1 tests) and for which the minimum air volume rate is 75 percent of the cooling full-load air volume rate, increase $e_{cyc,dry}$ by the quantity,

Equation 3.5-2. $$\frac{331W}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

and increase $q_{cyc,dry}$ by the quantity,

Equation 3.5-3. $$\frac{1130\ Btu/h}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

where $\dot{V}_S$ is the average indoor air volume rate from the section 3.4 dry coil steady-state test and is expressed in units of cubic feet per minute of standard air (scfm).

(2) For two-stage or variable-speed systems, for all cyclic dry-coil tests that specify the cooling full-load air volume rate (*i.e.,* the D_2 test) or tests using a minimum air volume rate that is greater than 75 percent of the cooling full-load air volume rate increase $e_{cyc,dry}$ by the quantity,

Equation 3.5-4. $$\frac{406\ W}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

and decrease $q_{cyc,dry}$ by the quantity,

Equation 3.5-5. $$\frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

(3) For single-stage systems, for all cyclic dry-coil tests (*i.e.,* the D test) increase $e_{cyc,dry}$ by the quantity calculated in Equation 3.5-4 and decrease $q_{cyc,dry}$ by the quantity calculated in Equation 3.5-5

b. For ducted, non-mobile, non-space-constrained home coil-only units,

(1) For two-stage or variable-speed systems, for all cyclic dry-coil tests that specify the cooling minimum air volume rate (*i.e.,* the D_1 and I_1 tests) and for which the minimum air volume rate is 75 percent of the cooling full-load air volume rate, increase $e_{cyc,dry}$ by the quantity,

Equation 3.5-6. $$\frac{360\ W}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

and decrease $q_{cyc,dry}$ by the quantity,

Equation 3.5-7. $$\frac{1228\ Btu/h}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

(2) For two-stage or variable-speed systems, for all cyclic dry-coil tests that specify the cooling full-load air volume rate (*i.e.,* the D_2 test) or tests using a minimum air volume rate that is greater than 75 percent of the cooling full-load air volume rate increase $e_{cyc,dry}$ by the quantity,

Equation 3.5-8. $$\frac{441\ W}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

and decrease $q_{cyc,dry}$ by the quantity,

Equation 3.5-9. $$\frac{1505\ Btu/h}{1000\ scfm} * \dot{V}_S * [\tau_2 - \tau_1]$$

(3) For single-stage systems, for all cyclic dry-coil tests (*i.e.,* the D test) increase $e_{cyc,dry}$ by the quantity calculated in Equation 3.5-8 and decrease $q_{cyc,dry}$ by the quantity calculated in Equation 3.5-9

c. For units having a variable-speed indoor blower that is disabled during the cyclic test, increase $e_{cyc,dry}$ and decrease $q_{cyc,dry}$ based on: The product of $[\tau_2 - \tau_1]$ and the indoor blower power (in W) measured during or following the dry coil steady-state test; or,

* * * * *

3.6 * * *

3.6.1 Tests for a Heat Pump Having a Single-Speed Compressor and Fixed Heating Air Volume Rate

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Table 11 -- Heating Mode Test Conditions for Units Having a Single-Speed Compressor and a Fixed-Speed Indoor Blower, a Constant Air Volume Rate Indoor Blower, or Coil-Only

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	

H1 test (required, steady)	70	60(max)	47	43	Heating Full-Load[1]
H1C test (optional, cyclic)	70	60(max)	47	43	([2])
H2 test (required)	70	60(max)	35	33	Heating Full-Load[1]
H3 test (required, steady)	70	60(max)	17	15	Heating Full-Load[1]
H4 test (optional, steady)	70	60(max)	5	4(max)	Heating Full-Load[1]

[1]Defined in section 3.1.4.4 of this appendix.
[2]Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the H1 test.

* * * * *

3.6.2 Tests for a Heat Pump Having a Single-Speed Compressor and a Single Indoor Unit Having Either (1) a Variable-Speed, Variable-Air-Rate Indoor Blower Whose Capacity Modulation Correlates With Outdoor Dry Bulb Temperature or (2) Multiple Indoor Blowers

* * * * *

Table 12 - Heating Mode Test Conditions for Units With a Single-Speed Compressor That Meet the Section 3.6.2 Indoor Unit Requirements

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	
$H1_2$ test (required, steady)	70	60(max)	47	43	Heating Full-Load[1]
$H1_1$ test (required, steady)	70	60(max)	47	43	Heating Minimum[2]
$H1C_1$ test (optional, cyclic)	70	60(max)	47	43	([3])
$H2_2$ test (required)	70	60(max)	35	33	Heating Full-Load[1]
$H2_1$ test (optional)	70	60(max)	35	33	Heating Minimum[2]

$H3_2$ test (required, steady)	70	$60^{(max)}$	17	15	Heating Full-Load[1]
$H3_1$ test (required, steady)	70	$60^{(max)}$	17	15	Heating Minimum[2]
$H4_2$ test (optional, steady)	70	$60^{(max)}$	5	$4^{(max)}$	Heating Full-Load[1]

[1]Defined in section 3.1.4.4 of this appendix.
[2]Defined in section 3.1.4.5 of this appendix.
[3]Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_1$ test.

* * * * *

3.6.3 Tests for a Heat Pump Having a Two-Capacity Compressor (see Section 1.2 of This Appendix, Definitions), Including Two-Capacity, Northern Heat Pumps (see Section 1.2 of This Appendix, Definitions)

* * * * *

Table 13 - Heating Mode Test Conditions for Units Having a Two-Capacity Compressor

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor capacity	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H0_1$ test (required, steady)	70	$60^{(max)}$	62	56.5	Low	Heating Minimum[1]
$H1_2$ test (required, steady)	70	$60^{(max)}$	47	43	High	Heating Full-Load[2]
$H1C_2$ test (optional,[7] cyclic)	70	$60^{(max)}$	47	43	High	([3])
$H1_1$ test (required, steady)	70	$60^{(max)}$	47	43	Low	Heating Minimum[1]
$H1C_1$ test (optional, cyclic)	70	$60^{(max)}$	47	43	Low	([4])
$H2_2$ test (required)	70	$60^{(max)}$	35	33	High	Heating Full-Load[2]
$H2_1$ test[5,6] (required)	70	$60^{(max)}$	35	33	Low	Heating Minimum[1]
$H3_2$ test (required, steady)	70	$60^{(max)}$	17	15	High	Heating Full-Load[2]
$H3_1$ test[5] (required, steady)	70	$60^{(max)}$	17	15	Low	Heating Minimum[1]

$H4_2$ test (optional, steady)	70	$60^{(max)}$	5	$4^{(max)}$	High	Heating Full-Load[2]

[1]Defined in section 3.1.4.5 of this appendix.
[2]Defined in section 3.1.4.4 of this appendix.
[3]Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_2$ test.
[4]Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_1$ test.
[5]Required only if the heat pump's performance when operating at low compressor capacity and outdoor temperatures less than 37 °F is needed to complete the section 4.2.3 HSPF2 calculations.
[6]If table note #5 applies, the section 3.6.3 equations for $Q_h^{k=1}$ (35) and $E_h^{k=1}$ (17) may be used in lieu of conducting the $H2_1$ test.
[7]Required only if the heat pump locks out low-capacity operation at lower outdoor temperatures.

*   *   *   *   *

3.6.4 Tests for a Heat Pump Having a Variable-Speed Compressor

3.6.4.1. Variable-Speed Compressor other than Non-communicating Coil-only Heat Pumps

a. Conduct one maximum temperature test ($H0_1$), two high temperature tests ($H1_N$ and $H1_1$), one frost accumulation test ($H2_V$), and one low temperature test ($H3_2$). Conducting one or more of the following tests is optional: an additional high temperature test ($H1_2$), an additional frost accumulation test ($H2_2$), and a very low temperature test ($H4_2$). Conduct the optional high temperature cyclic ($H1C_1$) test to determine the heating mode cyclic-degradation coefficient, C_D^h. If this optional test is conducted and yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. Test conditions for the nine tests are specified in Table 14A. The compressor shall operate for the $H1_2$, $H2_2$ and $H3_2$ Tests at the same heating full speed, measured by RPM or power input frequency (Hz), as the maximum speed at which the system controls would operate the compressor in normal operation in 17 °F ambient temperature. The compressor shall operate for the $H1_N$ test at the maximum speed at which the system controls would operate the compressor in normal operation in 47 °F ambient temperature. Additionally, for a cooling/heating heat pump, the compressor shall operate for the $H1_N$ test at a speed, measured by RPM or power input frequency (Hz), no lower than the speed used in the A_2 test if the tested $H1_N$ heating capacity is less than the tested A_2 cooling capacity. The compressor shall operate at the same heating minimum speed, measured by RPM or power input frequency (Hz), for the $H0_1$, $H1C_1$, and $H1_1$ Tests. Determine the heating intermediate compressor speed cited in Table 14A using the heating mode full and minimum compressors speeds and:

$$\text{Heating intermediate speed} = \text{Heating minimum speed} + \frac{\text{Heating full speed} - \text{Heating minimum speed}}{3}$$

where a tolerance of plus 5 percent or the next higher inverter frequency step from that calculated is allowed.

b. If one of the high temperature tests ($H1_2$ or $H1_N$) is conducted using the same compressor speed (RPM or power input frequency) as the $H3_2$ test, set the 47 °F capacity and power input values used for calculation of HSPF2 equal to the measured values for that test:

$$\dot{Q}_{hcalc}^{k=2}(47) = \dot{Q}_h^{k=2}(47); \ \dot{E}_{hcalc}^{k=2}(47) = \dot{E}_h^{k=2}(47)$$

where:

$\dot{Q}_{hcalc}^{k=2}(47)$ and $\dot{E}_{hcalc}^{k=2}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations,

$\dot{Q}_h^{k=2}(47)$ is the capacity measured in the high temperature test ($H1_2$ or $H1_N$) that used the same compressor speed as the $H3_2$ test, and

$\dot{E}_h^{k=2}(47)$ is the power input measured in the high temperature test ($H1_2$ or $H1_N$) which used the same compressor speed as the $H3_2$ test.

Evaluate the quantities $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ according to section 3.7 of this appendix.

Otherwise (if no high temperature test is conducted using the same speed (RPM or power input frequency) as the $H3_2$ test), calculate the 47 °F capacity and power input values used for calculation of HSPF2 as follows:

$$\dot{Q}_{hcalc}^{k=2}(47) = \dot{Q}_h^{k=2}(17) * (1 + 30°F * CSF);$$

$$\dot{E}_{hcalc}^{k=2}(47) = \dot{E}_h^{k=2}(17) * (1 + 30°F * PSF)$$

where:

$\dot{Q}_{hcalc}^{k=2}(47)$ and $\dot{E}_{hcalc}^{k=2}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations,

$\dot{Q}_h^{k=2}(17)$ is the capacity measured in the $H3_2$ test,

$\dot{E}_h^{k=2}(17)$ is the power input measured in the $H3_2$ test, CSF is the capacity slope factor, equal to 0.0204/°F for split systems and 0.0262/°F for single-package systems, and

PSF is the Power Slope Factor, equal to 0.00455/°F.

c. If the $H2_2$ test is not done, use the following equations to approximate the capacity and electrical power at the $H2_2$ test conditions:

$$\dot{Q}_h^{k=2}(35) = 0.90 * \{\dot{Q}_h^{k=2}(17) + 0.6 * [\dot{Q}_{hcalc}^{k=2}(47) - \dot{Q}_h^{k=2}(17)]\}$$

$$\dot{E}_h^{k=2}(35) = 0.985 * \{\dot{E}_h^{k=2}(17) + 0.6 * [\dot{E}_{hcalc}^{k=2}(47) - \dot{E}_h^{k=2}(17)]\}$$

where:

$\dot{Q}_{hcalc}^{k=2}(47)$ and $\dot{E}_{hcalc}^{k=2}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations, calculated as described in section b above, and

$\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ are the capacity and power input measured in the $H3_2$ test.

d. Determine the quantities $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ test, determine the quantities $\dot{Q}_h^{k=2}(5)$ and $\dot{E}_h^{k=2}(5)$ from the $H4_2$ test, and evaluate all four according to section 3.10 of this appendix.

e. For multiple-split heat pumps (only), the following procedures supersede the above requirements. For all Table 14A tests specified for a minimum compressor speed, turn off at least one indoor unit. The manufacturer shall designate the particular indoor unit(s) to be turned off. The manufacturer must also specify the compressor speed used for the Table 14A $H2_V$ test, a heating mode intermediate compressor speed that falls within ¼ and ¾ of the difference between the full and minimum heating mode speeds. The manufacturer should prescribe an intermediate speed that is expected to yield the highest COP for the given $H2_V$ test conditions and bracketed compressor speed range. The manufacturer can designate that one or more specific indoor units are turned off for the $H2_V$ test.

Table 14A Heating Mode Test Conditions for Units Having a Variable-Speed Compressor other than Variable-speed Non-communicating Coil-only Heat Pumps

Test description	Air entering indoor unit temperature (°F)		Air entering outdoor unit temperature (°F)		Compressor speed	Heating air volume rate
	Dry bulb	Wet bulb	Dry bulb	Wet bulb		
$H0_1$ test (required, steady)	70	$60^{(max)}$	62	56.5	Heating Minimum	Heating Minimum.[1]
$H1_2$ test (optional, steady)	70	$60^{(max)}$	47	43	Heating Full[4]	Heating Full-Load.[3]
$H1_1$ test (required, steady)	70	$60^{(max)}$	47	43	Heating Minimum	Heating Minimum.[1]
$H1_N$ test (required, steady)	70	$60^{(max)}$	47	43	Heating Full[5]	Heating Nominal[7]
$H1C_1$ test (optional, cyclic)	70	$60^{(max)}$	47	43	Heating Minimum	([2])
$H2_2$ test (optional)	70	$60^{(max)}$	35	33	Heating Full[4]	Heating Full-Load.[3]
$H2_V$ test (required)	70	$60^{(max)}$	35	33	Heating Intermediate	Heating Intermediate.[6]
$H3_2$ test (required, steady)	70	$60^{(max)}$	17	15	Heating Full[4]	Heating Full-Load.[3]
$H4_2$ test (optional, steady)	70	$60^{(max)}$	5	$4^{(max)}$	Heating Full[8]	Heating Full-Load.[3]

[1]Defined in section 3.1.4.5 of this appendix.

[2]Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_1$ test.

[3]Defined in section 3.1.4.4 of this appendix.

[4]Maximum speed that the system controls would operate the compressor in normal operation in 17 °F ambient temperature. The $H1_2$ test is not needed if the $H1_N$ test uses this same compressor speed.

[5]Maximum speed that the system controls would operate the compressor in normal operation in 47 °F ambient temperature.

[6]Defined in section 3.1.4.6 of this appendix.

[7]Defined in section 3.1.4.7 of this appendix.

[8]Maximum speed that the system controls would operate the compressor in normal operation at 5°F ambient temperature.

3.6.4.2. Variable-Speed Compressor with Non-communicating Coil-only Heat Pumps

a. Conduct one maximum temperature test ($H0_1$), two high temperature tests ($H1_N$ and $H1_1$), two frost accumulation test ($H2_2$ and $H2_1$), and two low temperature tests ($H3_2$ and $H3_1$). Conducting one or both of the following tests is optional: an additional high temperature test ($H1_2$) and a very low temperature test ($H4_2$). Conduct the optional high temperature cyclic ($H1C_1$) test to determine the heating mode cyclic-degradation coefficient, C_D^h. If this optional test is conducted and yields a tested C_D^h that exceeds the default C_D^h or if the optional test is not conducted, assign C_D^h the default value of 0.25. Test conditions for the ten tests are specified in Table 14B. The compressor shall operate for the $H1_2$ and $H3_2$ tests at the same heating full speed, measured by RPM or power input frequency (Hz), as the maximum speed at which the system controls would operate the compressor in normal operation in 17 °F ambient temperature. The compressor shall operate for the $H1_N$ test at the maximum speed at which the system controls would operate the compressor in normal operation in 47 °F ambient temperature. Additionally, for a cooling/heating heat pump, the compressor shall operate for the $H1_N$ test at a speed, measured by RPM or power input frequency (Hz), no lower than the speed used in the A_2 test if the tested $H1_N$ heating capacity is less than the tested A_2 cooling capacity. The compressor shall operate at the same heating minimum speed, measured by RPM or power input frequency (Hz), for the $H0_1$, $H1C_1$, and $H1_1$ tests.

b. If one of the high temperature tests ($H1_2$ or $H1_N$) is conducted using the same compressor speed (RPM or power input frequency) as the $H3_2$ test, set the 47 °F capacity and power input values used for calculation of HSPF2 equal to the measured values for that test:

$$\dot{Q}_{hcalc}^{k=2}(47) = \dot{Q}_{h}^{k=2}(47); \ \dot{E}_{hcalc}^{k=2}(47) = \dot{E}_{h}^{k=2}(47)$$

where:

$\dot{Q}_{hcalc}^{k=2}(47)$ and $\dot{E}_{hcalc}^{k=2}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations,

$\dot{Q}_{h}^{k=2}(47)$ is the capacity measured in the high temperature test ($H1_2$ or $H1_N$) which used the same compressor speed as the $H3_2$ test, and

$\dot{E}_{h}^{k=2}(47)$ is the power input measured in the high temperature test ($H1_2$ or $H1_N$) which used the same compressor speed as the $H3_2$ test.

Evaluate the quantities $\dot{Q}_h^{k=2}(47)$ and $\dot{E}_h^{k=2}(47)$ according to section 3.7 of this appendix.

Otherwise (if no high temperature test is conducted using the same speed (RPM or power input frequency) as the $H3_2$ test), calculate the 47 °F capacity and power input values used for calculation of HSPF2 as follows:

$$\dot{Q}_{hcalc}^{k=2}(47) = \dot{Q}_{h}^{k=2}(17) * (1 + 30^{\circ}F * CSF); \text{ and}$$

$$\dot{E}_{hcalc}^{k=2}(47) = \dot{E}_{h}^{k=2}(17) * (1 + 30^{\circ}F * PSF)$$

where:

$\dot{Q}_{hcalc}^{k=2}(47)$ and $\dot{E}_{hcalc}^{k=2}(47)$ are the capacity and power input, respectively, representing full-speed operation at 47 °F for the HSPF2 calculations,

$\dot{Q}_{h}^{k=2}(17)$ is the capacity measured in the $H3_2$ test,

$\dot{E}_{h}^{k=2}(17)$ is the power input measured in the $H3_2$ test,

CSF is the capacity slope factor, equal to 0.0204/°F for split systems, and

PSF is the Power Slope Factor, equal to 0.00455/°F.

c. Determine the quantities $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ test, determine the quantities $\dot{Q}_h^{k=2}(5)$ and $\dot{E}_h^{k=2}(5)$ from the $H4_2$ test, and evaluate all four according to section 3.10 of this appendix.

Table 14B Heating Mode Test Conditions for Variable-speed Non-communicating Coil-only Heat Pumps

Test description	**Air entering indoor unit temperature (°F)**		**Air entering outdoor unit temperature (°F)**		**Compressor speed**	**Heating air volume rate**
	Dry bulb	**Wet bulb**	**Dry bulb**	**Wet bulb**		
$H0_1$ test (required, steady)	70	60(max)	62	56.5	Heating Minimum	Heating Minimum.[1]
$H1_2$ test (optional, steady)	70	60(max)	47	43	Heating Full[4]	Heating Full-Load.[3]
$H1_1$ test (required, steady)	70	60(max)	47	43	Heating Minimum	Heating Minimum.[1]
$H1_N$ test (required, steady)	70	60(max)	47	43	Heating Full[5]	Heating Full-Load.[3]
$H1C_1$ test (optional, cyclic)	70	60(max)	47	43	Heating Minimum	([2])

$H2_2$ test (required)	70	$60^{(max)}$	35	33	Heating Full[6]	Heating Full-Load.[3]
$H2_1$ test (required)	70	$60^{(max)}$	35	33	Heating Minimum[7]	Heating Minimum.[1]
$H3_2$ test (required, steady)	70	$60^{(max)}$	17	15	Heating Full[4]	Heating Full-Load.[3]
$H3_1$ test (required, steady)	70	$60^{(max)}$	17	15	Heating Minimum[8]	Heating Minimum.[1]
$H4_2$ test (optional, steady)	70	$60^{(max)}$	5	$4^{(max)}$	Heating Full[9]	Heating Full-Load.[3]

[1]Defined in section 3.1.4.5 of this appendix.

[2]Maintain the airflow nozzle(s) static pressure difference or velocity pressure during an ON period at the same pressure or velocity as measured during the $H1_1$ test.

[3]Defined in section 3.1.4.4 of this appendix.

[4]Maximum speed that the system controls would operate the compressor in normal operation in 17 °F ambient temperature. The $H1_2$ test is not needed if the $H1_N$ test uses this same compressor speed.

[5]Maximum speed that the system controls would operate the compressor in normal operation in 47 °F ambient temperature.

[6]Maximum speed that the system controls would operate the compressor in normal operation in 35 °F ambient temperature.

[7]Minimum speed that the system controls would operate the compressor in normal operation in 35 °F ambient temperature.

[8]Minimum speed that the system controls would operate the compressor in normal operation in 17 °F ambient temperature.

[9]Maximum speed that the system controls would operate the compressor in normal operation in 5 °F ambient temperature.

*   *   *   *   *

3.6.6. Heating Mode Tests for Northern Heat Pumps with Triple-Capacity Compressors

*   *   *   *   *

Table 15 - Heating Mode Test Conditions for Units with a Triple-Capacity Compressor

Test Description	**Air Entering Indoor Unit (°F)**		**Air Entering Outdoor Unit (°F)**		**Compressor Capacity**	**Heating Air Volume Rate**
	Dry Bulb	**Wet Bulb**	**Dry Bulb**	**Wet Bulb**		
$H0_1$ Test (required, steady)	70	$60^{(max)}$	62	56.5	Low	Heating Minimum[1]
$H1_2$ (required, steady)	70	$60^{(max)}$	47	43	High	Heating Full-Load[2]
$H1C_2$ Test (optional,[8] cyclic	70	$60^{(max)}$	47	43	High	([3])
$H1_1$ Test (required, steady)	70	$60^{(max)}$	47	43	Low	Heating Minimum[1]
$H1C_1$ Test (optional, cyclic)	70	$60^{(max)}$	47	43	Low	([4])
$H2_3$ Test (optional, steady)	70	$60^{(max)}$	35	33	Booster	Heating Full-Load[2]
$H2_2$ Test (required)	70	$60^{(max)}$	35	33	High	Heating Full-Load[2]
$H2_1$ Test (required	70	$60^{(max)}$	35	33	Low	Heating Minimum[1]
$H3_3$ Test (required, steady)	70	$60^{(max)}$	17	15	Booster	Heating Full-Load[2]
$H3C_3$ Test[5,6] (optional, cyclic)	70	$60^{(max)}$	17	15	Booster	([7])
$H3_2$ Test (required, steady)	70	$60^{(max)}$	17	15	High	Heating Full-Load[2]
$H3_1$ Test[5] (required, steady)	70	$60^{(max)}$	17	15	Low	Heating Minimum[1]
$H4_3$ Test (required, steady)	70	$60^{(max)}$	5	$4^{(max)}$	Booster	Heating Full-Load[2]

[1] Defined in section 3.1.4.5 of this appendix.
[2] Defined in section 3.1.4.4 of this appendix.
[3] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the $H1_2$ test.
[4] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the $H1_1$ test.
[5] Required only if the heat pump's performance when operating at low compressor capacity and outdoor temperatures less than 37 °F is needed to complete the section 4.2.6 HSPF2 calculations.
[6] If table note[5] applies, the section 3.6.6 equations for $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(17)$ may be used in lieu of conducting the $H2_1$ test.
[7] Maintain the airflow nozzle(s) static pressure difference or velocity pressure during the ON period at the same pressure or velocity as measured during the $H3_3$ test.
[8] Required only if the heat pump locks out low-capacity operation at lower outdoor temperatures

*   *   *   *   *

3.7   *   *   *

c. For mobile home and space-constrained ducted coil-only system tests,

(1) For two-stage or variable-speed systems, for all steady-state maximum temperature and high temperature tests that specify the heating minimum air volume rate or the heating intermediate air volume rate (*i.e.,* the $H0_1$ and $H1_1$ tests) and for which the minimum or intermediate air volume rate is 75 percent of the cooling full-load air volume rate:

increase $Q_c{}^k(T)$ by: $\frac{1130\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{331\ W}{1000\ scfm} * \dot{V}_S$.

(2) For two-stage or variable-speed systems, for all steady-state maximum temperature and high temperature tests that specify the heating full-load air volume rate or the heating nominal air volume rate (*i.e.,* the $H1_2$ and the $H1_N$ tests) or tests using a minimum or intermediate air volume rate that is greater than 75 percent of the cooling full-load air volume rate:

increase $Q_c{}^k(T)$ by: $\frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{406\ W}{1000\ scfm} * \dot{V}_S$.

(3) For single-stage systems, for all steady-state maximum temperature and high temperature tests (*i.e.,* the H1 test) –

increase $Q_c{}^k(T)$ by: $\frac{1385\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{406\ W}{1000\ scfm} * \dot{V}_S$.

Where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

d. For non-mobile, non-space-constrained home ducted coil-only system tests,

(1) For two-stage or variable-speed systems, for all steady-state maximum temperature and high temperature tests that specify the heating minimum air volume rate or the heating intermediate air volume rate (*i.e.,* the $H0_1$ and $H1_1$ tests) and for which the minimum or intermediate air volume rate is 75 percent of the cooling full-load air volume rate:

increase $Q_c{}^k(T)$ by: $\frac{1228\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{360\ W}{1000\ scfm} * \dot{V}_S$.

(2) For two-stage or variable-speed systems, for all steady-state maximum temperature and high temperature tests that specify the heating full-load air volume rate or the heating nominal air volume rate (*i.e.,* the $H1_2$ and the $H1_N$ tests) or tests using a

minimum or intermediate air volume rate that is greater than 75 percent of the cooling full-load air volume rate:

increase $Q_c{}^k(T)$ by: $\frac{1505\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{441\ W}{1000\ scfm} * \dot{V}_S$.

(3) For single-stage systems, for all steady-state maximum temperature and high temperature tests (*i.e.,* the H1 test) –

increase $Q_c{}^k(T)$ by: $\frac{1505\ Btu/h}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_c{}^k(T)$ by: $\frac{441\ W}{1000\ scfm} * \dot{V}_S$.

where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

* * * * *

3.8 * * *

b. For ducted coil-only system heat pumps (excluding the special case where a variable-speed fan is temporarily removed),

(1) For mobile home and space-constrained ducted coil-only systems

(i) For two-stage or variable-speed systems, for all cyclic heating tests that specify the heating minimum air volume rate (*i.e.,* the $H1C_1$ test), increase q_{cyc} by the amount calculated using Equation 3.5-3. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5-2.

(ii) For two-stage or variable-speed systems, for all cyclic heating tests that specify the heating full-load air volume rate (*i.e.,* the $H1C_2$ test), increase q_{cyc} by the amount calculated using Equation 3.5-5. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5-4.

(iii) For single-stage systems, for all cyclic heating tests (*i.e.,* the H1C and $H1C_1$ tests), increase q_{cyc} by the amount calculated using Equation 3.5-5. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5-4.

(2) For non-mobile home and non-space-constrained ducted coil-only systems

(i) For two-stage or variable-speed systems, for all cyclic heating tests that specify the heating minimum air volume rate (*i.e.,* the $H1C_1$ test) - increase q_{cyc} by the amount calculated using Equation 3.5-7. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5-6.

(ii) For two-stage or variable-speed systems, for all cyclic heating tests that specify the heating full-load air volume rate (*i.e.,* the $H1C_2$ test) - increase q_{cyc} by the amount calculated using Equation 3.5-9. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5-8.

(iii) For single-stage systems, for all cyclic heating tests (*i.e.,* the H1C and $H1C_1$ tests) - increase q_{cyc} by the amount calculated using Equation 3.5-9. Additionally, increase e_{cyc} by the amount calculated using Equation 3.5-8.

In making these calculations, use the average indoor air volume rate ($\dot{V}_S$) determined from the section 3.7 of this appendix steady-state heating mode test conducted at the same test conditions.

* * * * *

3.9.1 * * *

b. Evaluate average electrical power, $\dot{E}_h{}^k(35) = \frac{e_{def}(35)}{\Delta_{\tau_{FR}}}$, when expressed in units of watts, using:

(1) For mobile home and space-constrained ducted coil-only system tests,

(i) For two-stage or variable-speed systems, for all frost accumulation tests that specify the heating minimum air volume rate or the heating intermediate air volume rate (*i.e.,* the $H2_1$ and $H2_V$ tests) and for which the minimum or intermediate air volume rate is 75 percent of the cooling full-load air volume rate,

increase $Q_h{}^k(35)$ by $\frac{1130\,{}^{Btu}/_{h}}{1000\,scfm} * \dot{V}_S$, and

increase $\dot{E}_h{}^k(35)$ by, $\frac{331\,W}{1000\,scfm} * \dot{V}_S$.

(ii) For two-stage and variable-speed systems, for all frost accumulation tests that specify the heating full-load air volume rate or the heating nominal air volume rate (*i.e.,* the $H2_2$ test) or tests using a minimum or intermediate air volume rate that is greater than 75 percent of the cooling full-load air volume rate:

increase $Q_h{}^k(35)$ by $\frac{1385\ ^{Btu}/_{h}}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_h{}^k(35)$ by, $\frac{406\ W}{1000\ scfm} * \dot{V}_S$.

(iii) For single-stage systems, for all frost accumulation tests (*i.e.,* the H2 test) –

increase $Q_h{}^k(35)$ by $\frac{1385\ ^{Btu}/_{h}}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_h{}^k(35)$ by, $\frac{406\ W}{1000\ scfm} * \dot{V}_S$.

where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

(2) For non-mobile home and non-space-constrained ducted coil-only systems,

(i) For two-stage or variable-speed systems, for all frost accumulation tests that specify the heating minimum air volume rate or the heating intermediate air volume rate (i.e., the H21 and H2V tests) and for which the minimum or intermediate air volume rate is 75 percent of the cooling full-load air volume rate,

increase $Q_h{}^k(35)$ by $\frac{1228\ ^{Btu}/_{h}}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_h{}^k(35)$ by,

$\frac{360\ W}{1000\ scfm} * \dot{V}_S$.

(ii) For two-stage and variable-speed systems, for all frost accumulation tests that specify the heating full-load air volume rate or the heating nominal air volume rate (i.e., the H22 test) or tests using a minimum or intermediate air volume rate that is greater than 75 percent of the cooling full-load air volume rate:

increase $Q_h{}^k(35)$ by $\frac{1505\ {}^{Btu}/_{h}}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_h{}^k(35)$ by, $\frac{441\ W}{1000\ scfm} * \dot{V}_S$.

(iii) For single-stage systems, for all frost accumulation tests (i.e., the H2 test) –

increase $Q_h{}^k(35)$ by $\frac{1505\ {}^{Btu}/_{h}}{1000\ scfm} * \dot{V}_S$, and

increase $\dot{E}_h{}^k(35)$ by, $\frac{441\ W}{1000\ scfm} * \dot{V}_S$.

where $\dot{V}_S$ is the average measured indoor air volume rate expressed in units of cubic feet per minute of standard air (scfm).

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4.1.4 SEER2 Calculations for an Air Conditioner or Heat Pump Having a Variable-Speed Compressor

Calculate SEER2 using Equation 4.1-1. Evaluate the space cooling capacity, $\dot{Q}_c{}^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_c{}^{k=1}(T_j)$, of the test unit when operating at minimum compressor speed and outdoor temperature T_j.. Use, Equation 4.1.4-1 $\dot{Q}_c^{k=1}(T_j) = \dot{Q}_c^{k=1}(67) + \frac{\dot{Q}_c^{k=1}(82) - \dot{Q}_c^{k=1}(67)}{82 - 67} * (T_j - 67)$

Equation 4.1.4-2 $\dot{E}_c^{k=1}(T_j) = \dot{E}_c^{k=1}(67) + \frac{\dot{E}_c^{k=1}(82) - \dot{E}_c^{k=1}(67)}{82 - 67} * (T_j - 67)$

where $\dot{Q}_c^{k=1}(82)$ and $\dot{E}_c^{k=1}(82)$ are determined from the B_1 test, $\dot{Q}_c^{k=1}(67)$ and $\dot{E}_c^{k=1}(67)$ are determined from the F1 test, and all four quantities are calculated as specified in section 3.3 of this appendix. Evaluate the space cooling capacity, $\dot{Q}_c^{k=2}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=2}(T_j)$, of the test unit when operating at full compressor speed and outdoor temperature T_j. Use Equations 4.1.3-3 and 4.1.3-4, respectively, where $\dot{Q}_c^{k=2}(95)$ and $\dot{E}_c^{k=2}(95)$ are determined from the A_2 test, $\dot{Q}_c^{k=2}(82)$ and $\dot{E}_c^{k=2}(82)$ are determined from the B_2 test, and all four quantities are calculated as specified in section 3.3 of this appendix. For units other than variable-speed non-communicating coil-only air-conditioners or heat pumps, calculate the space cooling capacity, $\dot{Q}_c^{k=v}(T_j)$, and electrical power consumption, $\dot{E}_c^{k=v}(T_j)$, of the test unit when operating at outdoor temperature T_j and the intermediate compressor speed used during the section 3.2.4 (and Table 8) E_V test of this appendix using,

Equation 4.1.4-3 $\dot{Q}_c^{k=v}(T_j) = \dot{Q}_c^{k=v}(87) + M_Q * (T_j - 87)$

Equation 4.1.4-4 $\dot{E}_c^{k=v}(T_j) = \dot{E}_h^{k=v}(87) + M_E * (T_j - 87)$

where $\dot{Q}_c^{k=v}(87)$ and $\dot{E}_c^{k=v}(87)$ are determined from the E_V test and calculated as specified in section 3.3 of this appendix. Approximate the slopes of the k=v intermediate speed cooling capacity and electrical power input curves, M_Q and M_E, as follows:

$$M_Q = \left[\frac{\dot{Q}_c^{k=1}(82) - \dot{Q}_c^{k=1}(67)}{82 - 67} * (1 - N_Q)\right] + \left[N_Q * \frac{\dot{Q}_c^{k=2}(95) - \dot{Q}_c^{k=2}(82)}{95 - 82}\right]$$

$$M_E = \left[\frac{\dot{E}_c^{k=1}(82) - \dot{E}_c^{k=1}(67)}{82 - 67} * (1 - N_E)\right] + \left[N_E * \frac{\dot{E}_c^{k=2}(95) - \dot{E}_c^{k=2}(82)}{95 - 82}\right]$$

where,

$N_Q = \frac{\dot{Q}_c^{k=v}(87) - \dot{Q}_c^{k=1}(87)}{\dot{Q}_c^{k=2}(87) - \dot{Q}_c^{k=1}(87)}$ and $N_E = \frac{\dot{E}_c^{k=v}(87) - \dot{E}_c^{k=1}(87)}{\dot{E}_c^{k=2}(87) - \dot{E}_c^{k=1}(87)}$

Use Equations 4.1.4-1 and 4.1.4-2, respectively, to calculate $\dot{Q}_c^{k=1}(87)$ and $\dot{E}_c^{k=1}(87)$.

*   *   *   *   *

4.1.4.2.1 Units that are not variable-speed non-communicating coil-only air conditioners or heat pumps

If the unit operates at an intermediate compressor speed (k=i) in order to match the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

$$\frac{q_c(T_j)}{N} = \dot{Q}_c^{k=i}(T_j) * \frac{n_j}{N} \qquad \frac{e_c(T_j)}{N} = \dot{E}_c^{k=i}(T_j) * \frac{n_j}{N}$$

where:

$\dot{Q}_c^{k=i}(T_j) = BL(T_j)$, the space cooling capacity delivered by the unit in matching the building load at temperature T_j, in Btu/h. The matching occurs with the unit operating at compressor speed k = i.

$\dot{E}_c^{k=i}(T_j) = \frac{\dot{Q}_c^{k=i}(T_j)}{EER^{k=i}(T_j)}$ the electrical power input required by the test unit when operating at a compressor speed of k = i and temperature T_j, in W.

$EER^{k=i}(T_j)$ = the steady-state energy efficiency ratio of the test unit when operating at a compressor speed of k = i and temperature T_j, Btu/h per W.

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 19 of this section. For each temperature bin where the unit operates at an intermediate compressor speed, determine the energy efficiency ratio $EER^{k=i}(T_j)$ using the following equations,

For each temperature bin where $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=v}(T_j)$,

$$EER^{k=i}(T_j) = EER^{k=1}(T_j) + \frac{EER^{k=v}(T_j) - EER^{k=1}(T_j)}{Q^{k=v}(T_j) - Q^{k=1}(T_j)} * (BL(T_j) - Q^{k=1}(T_j))$$

For each temperature bin where $\dot{Q}_c^{k=v}(T_j) \leq BL(T_j) < \dot{Q}_c^{k=2}(T_j)$,

$$EER^{k=i}(T_j) = EER^{k=v}(T_j) + \frac{EER^{k=2}(T_j) - EER^{k=v}(T_j)}{Q^{k=2}(T_j) - Q^{k=v}(T_j)} * (BL(T_j) - Q^{k=v}(T_j))$$

where:

$EER^{k=1}(T_j)$ is the steady-state energy efficiency ratio of the test unit when operating at minimum compressor speed and temperature Tj, in Btu/h per W, calculated using capacity $\dot{Q}_c^{k=1}(T_j)$ calculated using Equation 4.1.4-1 and electrical power consumption $\dot{E}_c^{k=1}(T_j)$ calculated using Equation 4.1.4-2;

$EER^{k=v}(T_j)$ is the steady-state energy efficiency ratio of the test unit when operating at intermediate compressor speed and temperature Tj, in Btu/h per W, calculated using capacity $\dot{Q}_c^{k=v}(T_j)$ calculated using Equation 4.1.4-3 and electrical power consumption $\dot{E}_c^{k=v}(T_j)$ calculated using Equation 4.1.4-4;

$EER^{k=2}(T_j)$ is the steady-state energy efficiency ratio of the test unit when operating at full compressor speed and temperature Tj, Btu/h per W, calculated using capacity $\dot{Q}_c^{k=2}(T_j)$ and electrical power consumption $\dot{E}_c^{k=2}(T_j)$, both calculated as described in section 4.1.4 of this appendix; and

$BL(T_j)$ is the building cooling load at temperature T_j, Btu/h.

4.1.4.2.2 Variable-speed Non-communicating Coil-only Air Conditioners or Heat Pumps

If the unit alternates between high (k=2) and low (k=1) compressor capacity to satisfy the building cooling load at temperature T_j, $\dot{Q}_c^{k=1}(T_j) < BL(T_j) < \dot{Q}_c^{k=2}(T_j)$.

$$\frac{q_c(T_j)}{N} = [X^{k=1}(T_j) * \dot{Q}_c^{k=1}(T_j) + X^{k=2}(T_j) * \dot{Q}_c^{k=2}(T_j)] * \frac{n_j}{N}$$

$$\frac{e_c(T_j)}{N} = [X^{k=1}(T_j) * \dot{E}_c^{k=1}(T_j) + X^{k=2}(T_j) * \dot{E}_c^{k=2}(T_j)] * \frac{n_j}{N}$$

where:

$X^{k=1}(T_j) = \frac{\dot{Q}_c^{k=2}(T_j) - BL(T_j)}{\dot{Q}_c^{k=2}(T_j) - \dot{Q}_c^{k=1}(T_j)}$ the cooling mode, low capacity load factor for temperature bin j (dimensionless); and

$X^{k=2}(T_j) = 1 - X^{k=1}(T_j)$, the cooling mode, high capacity load factor for temperature bin j (dimensionless).

Obtain the fractional bin hours for the cooling season, n_j/N, from Table 19.

Obtain $\dot{Q}_c^{k=1}(T_j)$, $\dot{E}_c^{k=1}(T_j)$, $\dot{Q}_c^{k=2}(T_j)$, and $\dot{E}_c^{k=2}(T_j)$ as described in section 4.1.4 of this appendix.

*   *   *   *   *

4.2   *   *   *

Evaluate the building heating load using

Equation 4.2-2 $$BL(T_j) = \frac{T_{zl} - T_j}{T_{zl} - 5°\mathrm{F}} * C * \dot{Q}_c(95°\mathrm{F})$$

where,

T_j = the outdoor bin temperature, °F;

T_{zl} = the zero-load temperature, °F, which varies by climate region according to Table 20;

C = slope (adjustment) factor, which varies by climate region according to Table 20. When calculating building load for a variable-speed compressor system, substitute C_{VS} for C;

$Q_c(95°F)$ = the cooling capacity at 95 °F determined from the A or A_2 test, Btu/h. For heating-only heat pump units, replace $Q_c(95°F)$ in Equation 4.2-2 with $Q_h(47°F)$;

$Q_h(47°F)$ = the heating capacity at 47 °F determined from the H1 test for units having a single-speed compressor, $H1_2$ for units having a two-capacity compressor, and $H1_N$ test for units having a variable-speed compressor, Btu/h.

*   *   *   *   *

4.2.3   *   *   *

The calculation of the Equation 4.2-1 quantities differ depending upon whether the heat pump would operate at low capacity (section 4.2.3.1 of this appendix), cycle between low and high capacity (section 4.2.3.2 of this appendix), or operate at high capacity (sections 4.2.3.3 and 4.2.3.4 of this appendix) in responding to the building load. For heat pumps that lock out low capacity operation at low outdoor temperatures, the outdoor temperature at which the unit locks out must be that specified by the manufacturer in the certification report so that the appropriate equations can be selected.

* * * * *

4.2.3.4 Heat Pump Must Operate Continuously at High (k=2) Compressor Capacity at Temperature T_j, $BL(T_j) \geq Q_h^{k=2}(T_j)$

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=2}(T_j) * \delta'(T_j) * \frac{n_j}{N}$$

$$\frac{RH(T_j)}{N} = \frac{BL(T_j) - \left[\dot{Q}_h^{k=2} * \delta'(T_j)\right]}{3.413\,\frac{Btu}{Wh}} * \frac{n_j}{N}$$

where:

$$\delta'(T_j) = \begin{cases} 0, & if\ T_j \leq T_{off}\ or\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} < 1 \\ \dfrac{1}{2}, & if\ T_{off} < T_j \leq T_{on}\ and\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} \geq 1 \\ 1, & if\ T_j > T_{on}\ and\ \dfrac{\dot{Q}_h^{k=2}(T_j)}{3.413 * \dot{E}_h^{k=2}(T_j)} \geq 1 \end{cases}$$

* * * * * $\frac{()}{}\cdot()()-\frac{()}{}()\frac{[()]}{-}-$

4.2.4 * * *

a. Minimum Compressor Speed.

For units other than variable-speed non-communicating coil-only heat pumps, evaluate the space heating capacity, $Q_h^{k=1}(T_j)$, and electrical power consumption, $E_h^{k=1}(T_j)$, of the heat pump when operating at minimum compressor speed and outdoor temperature T_j using

Equation 4.2.4-1 $\dot{Q}_h^{k=1}(T_j) = \dot{Q}_h^{k=1}(47) + \frac{\dot{Q}_h^{k=1}(62) - \dot{Q}_h^{k=1}(47)}{62-47} * (T_j - 47)$; and

Equation 4.2.4-2 $\dot{E}_h^{k=1}(T_j) = \dot{E}_h^{k=1}(47) + \frac{\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)}{62-47} * (T_j - 47)$

where $Q_h^{k=1}(62)$ and $E_h^{k=1}(62)$ are determined from the $H0_1$ test, $Q_h^{k=1}(47)$ and $E_h^{k=1}(47)$ are determined from the $H1_1$ test, and all four quantities are calculated as specified in section 3.7 of this appendix.

For variable-speed non-communicating coil-only heat pumps, when T_j is greater than or equal to 47 ºF, evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$, of the heat pump when operating at minimum compressor speed as described in Equations 4.2.4-1 and 4.2.4-2, respectively. When T_j is less than 47 ºF, evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$ using

Equation 4.2.4-3

$$\dot{Q}_h^{k=1}(T_j) = \begin{cases} \dot{Q}_h^{k=1}(35) + \dfrac{\left[\dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=1}(35)\right] * (T_j - 35)}{47 - 35}, & if\ 35\ °F \leq T_j < 47\ °F \\ \dot{Q}_h^{k=1}(17) + \dfrac{\left[\dot{Q}_h^{k=1}(35) - \dot{Q}_h^{k=1}(17)\right] * (T_j - 17)}{35 - 17}, & if\ 17\ °F \leq T_j < 35\ °F \\ \dot{Q}_h^{k=2}(T_j) * \left(\dot{Q}_h^{k=1}(17) / \dot{Q}_h^{k=2}(17)\right), & if\ T_j < 17\ °F \end{cases}$$

and

Equation 4.2.4-4

$$\dot{E}_h^{k=1}(T_j) = \begin{cases} \dot{E}_h^{k=1}(35) + \dfrac{\left[\dot{E}_h^{k=1}(47) - \dot{E}_h^{k=1}(35)\right] * (T_j - 35)}{47 - 35}, & if\ 35\ °F \leq T_j < 47\ °F \\ \dot{E}_h^{k=1}(17) + \dfrac{\left[\dot{E}_h^{k=1}(35) - \dot{E}_h^{k=1}(17)\right] * (T_j - 17)}{35 - 17}, & if\ 17\ °F \leq T_j < 35\ °F \\ \dot{E}_h^{k=2}(T_j) * \left(\dot{E}_h^{k=1}(17) / \dot{E}_h^{k=2}(17)\right), & if\ T_j < 17\ °F \end{cases}$$

where $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ are determined from the $H1_1$ test, and both quantities are calculated as specified in section 3.7 of this appendix; $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$ are determined from the $H2_1$ test, and are calculated as specified in section 3.9 of this appendix; $\dot{Q}_h^{k=1}(17)$ and $\dot{E}_h^{k=1}(17)$ are determined from the $H3_1$ test, and are calculated as specified in section 3.10 of this appendix; and $\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$ are calculated as described in section 4.2.4.c or 4.2.4.d of this appendix, as appropriate.

b. Minimum Compressor Speed for Minimum-speed-limiting Variable-speed Heat Pumps: For units other than variable-speed non-communicating coil-only heat pumps, evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$, of the heat pump when operating at minimum compressor speed and outdoor temperature T_j using

Equation 4.2.4-5

$$\dot{Q}_h^{k=1}(T_j) = \begin{cases} \dot{Q}_h^{k=1}(47) + \dfrac{\left[\dot{Q}_h^{k=1}(62) - \dot{Q}_h^{k=1}(47)\right] * (T_j - 47)}{62 - 47}, & if\ T_j \geq 47\ °\mathrm{F} \\ \dot{Q}_h^{k=v}(35) + \dfrac{\left[\dot{Q}_h^{k=1}(47) - \dot{Q}_h^{k=v}(35)\right] * (T_j - 35)}{47 - 35}, & if\ 35\ °\mathrm{F} \leq T_j < 47\ °\mathrm{F} \\ \dot{Q}_h^{k=v}(T_j), & if\ T_j < 35\ °\mathrm{F} \end{cases}$$

and

Equation 4.2.4-6

$$\dot{E}_h^{k=1}(T_j) = \begin{cases} \dot{E}_h^{k=1}(47) + \dfrac{\left[\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)\right] * (T_j - 47)}{62 - 47}, & if\ T_j \geq 47\ °\text{F} \\ \dot{E}_h^{k=v}(35) + \dfrac{\left[\dot{E}_h^{k=1}(47) - \dot{E}_h^{k=v}(35)\right] * (T_j - 35)}{47 - 35}, & if\ 35\ °\text{F} \leq T_j < 47\ °\text{F} \\ \dot{E}_h^{k=v}(T_j), & if\ T_j < 35\ °\text{F} \end{cases}$$

where $\dot{Q}_h^{k=1}(62)$ and $\dot{E}_h^{k=1}(62)$ are determined from the $H0_1$ test, $\dot{Q}_h^{k=1}(47)$ and $\dot{E}_h^{k=1}(47)$ are determined from the $H1_1$ test, and all four quantities are calculated as specified in section 3.7 of this appendix; $\dot{Q}_h^{k=v}(35)$ and $\dot{E}_h^{k=v}(35)$ are determined from the $H2_v$ test and are calculated as specified in section 3.9 of this appendix; and $\dot{Q}_h^{k=v}(T_j)$ and $\dot{E}_h^{k=v}(T_j)$ are calculated using equations 4.2.4-7 and 4.2.4-8, respectively.

For variable-speed non-communicating coil-only heat pumps, evaluate the space heating capacity, $\dot{Q}_h^{k=1}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=1}(T_j)$, of the heat pump as described in section 4.2.4.a, using Equations 4.2.4-1, 4.2.4-2, 4.2.4-3 and 4.2.4-4, as appropriate.

c. Full Compressor Speed for Heat Pumps for which the $H4_2$ test is not conducted.

Evaluate the space heating capacity, $\dot{Q}_h^{k=2}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=2}(T_j)$, of the heat pump when operating at full compressor speed and outdoor temperature T_j using

$$\dot{Q}_h^{k=2}(T_j) =$$

$$\begin{cases} \left\{\dot{Q}_h^{k=2}(17) + \frac{\left[\dot{Q}_{hcalc}^{k=2}(47) - \dot{Q}_h^{k=2}(17)\right] * (T_j - 17)}{47 - 17}\right\} * \left(\frac{\dot{Q}_h^{k=N}(47)}{\dot{Q}_{hcalc}^{k=2}(47)}\right), & if\ T_j \geq 45\ °\mathrm{F} \\ \dot{Q}_h^{k=2}(17) + \frac{\left[\dot{Q}_h^{k=2}(35) - \dot{Q}_h^{k=2}(17)\right] * (T_j - 17)}{35 - 17}, & if\ 17\ °\mathrm{F} \leq T_j < 45\ °\mathrm{F} \\ \dot{Q}_h^{k=2}(17) + \frac{\left[\dot{Q}_{hcalc}^{k=2}(47) - \dot{Q}_h^{k=2}(17)\right] * (T_j - 17)}{47 - 17}, & if\ T_j < 17\ °\mathrm{F} \end{cases}$$

and

$$\dot{E}_h^{k=2}(T_j) =$$

$$\begin{cases} \left\{\dot{E}_h^{k=2}(17) + \frac{\left[\dot{E}_{hcalc}^{k=2}(47) - \dot{E}_h^{k=2}(17)\right] * (T_j - 17)}{47 - 17}\right\} * \left(\frac{\dot{E}_h^{k=N}(47)}{\dot{E}_{hcalc}^{k=2}(47)}\right), & if\ T_j \geq 45\ °\mathrm{F} \\ \dot{E}_h^{k=2}(17) + \frac{\left[\dot{E}_h^{k=2}(35) - \dot{E}_h^{k=2}(17)\right] * (T_j - 17)}{35 - 17}, & if\ 17\ °\mathrm{F} \leq T_j < 45\ °\mathrm{F} \\ \dot{E}_h^{k=2}(17) + \frac{\left[\dot{E}_{hcalc}^{k=2}(47) - \dot{E}_h^{k=2}(17)\right] * (T_j - 17)}{47 - 17}, & if\ T_j < 17\ °\mathrm{F} \end{cases}$$

Determine $\dot{Q}_h^{k=N}(47)$ and $\dot{E}_h^{k=N}(47)$ from the $H1_N$ test and the calculations specified in section 3.7 of this appendix. See section 3.6.4.b of this appendix regarding determination of the capacity $\dot{Q}_{hcalc}^{k=2}(47)$ and power input $\dot{E}_{hcacl}^{k=2}(47)$ used in the HSPF2 calculations to represent the $H1_2$ Test. Determine $\dot{Q}_h^{k=2}(35)$ and $\dot{E}_h^{k=2}(35)$ from the $H2_2$ test and the calculations specified in section 3.9 of this appendix or, if the $H2_2$ test is not conducted, by conducting the calculations specified in section 3.6.4 of this appendix. Determine $\dot{Q}_h^{k=2}(17)$ and $\dot{E}_h^{k=2}(17)$ from the $H3_2$ test and the methods specified in section 3.10 of this appendix.

*   *   *   *   *

e. Intermediate Compressor Speed. For units other than variable-speed non-communicating coil-only heat pumps, calculate the space heating capacity, $\dot{Q}_h^{k=v}(T_j)$, and electrical power consumption, $\dot{E}_h^{k=v}(T_j)$, of the heat pump when operating at outdoor temperature T_j and the intermediate compressor speed used during the section 3.6.4 $H2_V$ test using

Equation 4.2.4-7 $\dot{Q}_h^{k=v}(T_j) = \dot{Q}_h^{k=v}(35) + M_Q * (T_j - 35)$, and

Equation 4.2.4-8 $\dot{E}_h^{k=v}(T_j) = \dot{E}_h^{k=v}(35) + M_E * (T_j - 35)$

where $\dot{Q}_h^{k=v}(35)$ and $\dot{E}_h^{k=v}(35)$ are determined from the $H2_V$ test and calculated as specified in section 3.9 of this appendix. Approximate the slopes of the k=v intermediate speed heating capacity and electrical power input curves, M_Q and M_E, as follows:

$$M_Q = \left[\frac{\dot{Q}_h^{k=1}(62) - \dot{Q}_h^{k=1}(47)}{62 - 47} * (1 - N_Q)\right] + \left[N_Q * \frac{\dot{Q}_h^{k=2}(35) - \dot{Q}_h^{k=2}(17)}{35 - 17}\right]$$

$$M_E = \left[\frac{\dot{E}_h^{k=1}(62) - \dot{E}_h^{k=1}(47)}{62 - 47} * (1 - N_E)\right] + \left[N_E * \frac{\dot{E}_h^{k=2}(35) - \dot{E}_h^{k=2}(17)}{35 - 17}\right]$$

where,

$$N_Q = \frac{\dot{Q}_h^{k=v}(35) - \dot{Q}_h^{k=1}(35)}{\dot{Q}_h^{k=2}(35) - \dot{Q}_h^{k=1}(35)} \quad \text{and} \quad N_E = \frac{\dot{E}_h^{k=v}(35) - \dot{E}_h^{k=1}(35)}{\dot{E}_h^{k=2}(35) - \dot{E}_h^{k=1}(35)}$$

Use Equations 4.2.4-1 and 4.2.4-2, respectively, to calculate $\dot{Q}_h^{k=1}(35)$ and $\dot{E}_h^{k=1}(35)$, whether or not the heat pump is a minimum-speed-limiting variable-speed heat pump.

For variable-speed non-communicating coil-only heat pumps, there is no intermediate speed.

4.2.4.1 Steady-state space heating capacity when operating at minimum compressor speed is greater than or equal to the building heating load at temperature T_j, $\dot{Q}_h^{k=1}(T_j \geq BL(T_j)$.

Evaluate the Equation 4.2-1 quantities

$\frac{RH(T_j)}{N}$ and $\frac{e_h(T_j)}{N}$

as specified in section 4.2.3.1 of this appendix. Except now use Equations 4.2.4-1 and 4.2.4-2 (for heat pumps that are not minimum-speed-limiting and are not variable-speed non-communicating coil-only heat pumps), Equations 4.2.4-1, 4.2.4-2, 4.2.4-3 and 4.2.4-4 as appropriate (for variable-speed non-communicating coil-only heat pumps), or Equations 4.2.4-5 and 4.2.4.-6 (for minimum-speed-limiting variable-speed heat pumps that are not variable-speed non-communicating coil-only heat pumps) to evaluate $\dot{Q}_h^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j)$, respectively, and replace section 4.2.3.1 references to "low capacity" and section 3.6.3 of this appendix with "minimum speed" and section 3.6.4 of this appendix.

4.2.4.2 Heat pump operates at an intermediate compressor speed (k=i) or, for a variable-speed non-communicating coil-only heat pump, cycles between high and low speeds, in order to match the building heating load at a temperature T_j, $\dot{Q}_h^{k=1}(T_j) < BL(T_j) < \dot{Q}_h^{k=2}(T_j)$.

For units that are not variable-speed non-communicating coil-only heat pumps, calculate

$\frac{RH(T_j)}{N}$ using Equation 4.2.3-2 while evaluating $\frac{e_h(T_j)}{N}$ using,

$$\frac{e_h(T_j)}{N} = \dot{E}_h^{k=i}(T_j) * \delta(T_j) * \frac{n_j}{N}$$

where:

$$\dot{E}_h^{k=i}(T_j) = \frac{\dot{Q}_h^{k=i}(T_j)}{3.413\,\frac{Btu/h}{W} * COP^{k=i}(T_j)}$$

and $\delta(T_j)$ is evaluated using Equation 4.2.3-3, while

$\dot{Q}_h^{k=i}(T_j) = BL(T_j)$, the space heating capacity delivered by the unit in matching the building load at temperature (T_j), in Btu/h. The matching occurs with the heat pump operating at compressor speed k=i, and

$COP^{k=i}(T_j)$ = the steady-state coefficient of performance of the heat pump when operating at compressor speed k=i and temperature T_j (dimensionless).

For each temperature bin where the heat pump operates at an intermediate compressor speed, determine $COP^{k=i}(T_j)$ using the following equations,

For each temperature bin where $\dot{Q}_h^{k=1}(T_j) < BL(T_j) < \dot{Q}_h^{k=v}(T_j)$,

$$COP_h^{k=i}(T_j) = COP_h^{k=1}(T_j) + \frac{COP_h^{k=v}(T_j) - COP_h^{k=1}(T_j)}{Q_h^{k=v}(T_j) - Q_h^{k=1}(T_j)} * (BL(T_j) - Q_h^{k=1}(T_j))$$

For each temperature bin where $\dot{Q}_h^{k=v}(T_j) \leq BL(T_j) < \dot{Q}_h^{k=2}(T_j)$,

$$COP_h^{k=i}(T_j) = COP_h^{k=v}(T_j) + \frac{COP_h^{k=2}(T_j) - COP_h^{k=v}(T_j)}{Q_h^{k=2}(T_j) - Q_h^{k=v}(T_j)} * (BL(T_j) - Q_h^{k=v}(T_j))$$

where:

$COP_h^{k=1}(T_j)$ is the steady-state coefficient of performance of the heat pump when operating at minimum compressor speed and temperature Tj, dimensionless, calculated using capacity $\dot{Q}_h^{k=1}(T_j)$ calculated using Equation 4.2.4-1 or 4.2.4-3 and electrical power consumption $\dot{E}_h^{k=1}(T_j)$ calculated using Equation 4.2.4-2 or 4.2.4-4;

$COP_h^{k=v}(T_j)$ is the steady-state coefficient of performance of the heat pump when operating at intermediate compressor speed and temperature Tj, dimensionless, calculated using capacity $\dot{Q}_h^{k=v}(T_j)$ calculated using Equation 4.2.4-7 and electrical power consumption $\dot{E}_h^{k=v}(T_j)$ calculated using Equation 4.2.4-8;

$COP_h^{k=2}(T_j)$ is the steady-state coefficient of performance of the heat pump when operating at full compressor speed and temperature Tj (dimensionless), calculated using capacity $\dot{Q}_h^{k=2}(T_j)$ and electrical power consumption $\dot{E}_h^{k=2}(T_j)$, both calculated as described in section 4.2.4; and

BL(T_j) is the building heating load at temperature T_j, in Btu/h.

For variable-speed non-communicating heat pumps, calculate $\frac{RH(T_j)}{N}$ and $\frac{e_h(T_j)}{N}$ as described in section 4.2.3.2 of this appendix with the understanding that $\dot{Q}_h^{k=2}(T_j)$ and $\dot{E}_h^{k=2}(T_j)$ correspond to full compressor speed operation, $\dot{Q}_h^{k=1}(T_j)$ and $\dot{E}_h^{k=1}(T_j)$ correspond to minimum compressor speed operation, and all four quantities are derived from the results of the specified section 3.6.4 tests of this appendix.

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